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Diet, nutrition, and the prevention of chronic diseases

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WHO Study Group

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WHO STUDY GROUP ON DIET, NUTRITION AND PREVENTION OF NONCOMMUNICABLE DISEASES

Geneva, 6–13 March 1989

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DIET, NUTRITION, AND THE PREVENTION OF CHRONIC DISEASES

Report of a WHO Study Group on Diet, Nutrition and Prevention of Noncommunicable Diseases

A WHO Study Group on Diet, Nutrition and Prevention of Noncommunicable Diseases met in Geneva from 6 to 13 March 1989. The meeting was opened by Dr Hu Ching-Li, on behalf of the Director-General, Dr Hiroshi Nakajima. He said that the amount and type of food eaten were fundamental determinants of human health. Since health was a fundamental determinant of the quality of each individual's life, good health should be a primary social goal. Improvements in the collective good health of a population—particularly the avoidance of chronic diseases in adult life—also decreased the costs associated with both health care and lost economic productivity. Good health was therefore an important economic asset.

Changes in dietary habits towards the "affluent" diet that prevailed in many developed countries had been followed by increases in the incidence of various chronic diseases of middle and later adult life. Initially, those chronic diseases coexisted with the long-standing and persistent problems associated with nutritional deficiencies, which could affect all age groups. The continuing public health importance of such deficiency disorders was recognized. However, the task of the Study Group was to provide recommendations that would help to prevent the chronic diseases that were related to the newly emerging dietary changes in developing countries, and to help in reducing the impact of these diseases in developed countries.

The Study Group's report would describe recent changes in the dietary and health patterns of countries, define the relationship between the "affluent" diet that typically accompanied economic development and the subsequent emergence of chronic diseases, and explore the need for national food and nutrition policies to prevent or minimize costly health problems in both developing and developed countries.

1. INTRODUCTION

1.1 Background

Over the course of evolution, human beings (and their primate predecessors) adapted progressively to a wide range of naturally occurring foods, but the types of food and the mix of nutrients (in terms of carbohydrates, fats, and protein) remained relatively constant throughout the ages. Food supply was often precarious, and starvation frequent.

The agricultural revolution, approximately 10 000 years ago, brought profound changes. The ability to produce and store food became more widespread, and some foods were preferentially cultivated. The industrial revolution in developed countries in the last 200 years has introduced radical changes in methods of food production, processing, storage, and distribution. Recent technological innovations, along with increased material well-being and life-styles that have allowed the exercise of dietary preferences (amplified by modern marketing techniques), have led to major changes in the nutritional composition of the diet in developed countries. For example, it is estimated that the per caput consumption of fat and sugar (refined carbohydrate) has increased 5–10-fold in England over the past 200 years, while the consumption of complex carbohydrates (including cereal grains) has declined substantially. Compared with the scale of human history and biological evolution, these developments represent dramatic and extremely rapid changes in population food supply.

The immediate health benefit of this increased and assured supply of food has been the elimination of starvation and the near-elimination of many micronutrient (e.g., vitamin) deficiency diseases in the developed countries of the world. The general improvement in nutritional status, with its associated increase in childhood growth rates, has brought an increased resistance to infectious disease. The overall effect has been to increase life expectancy substantially in many countries.

1.2 Diet-related chronic diseases: a recently identified problem

The longer-term adverse health effects of the "affluent" diet prevailing in the developed industrialized countries—characterized by an excess of energy-dense foods rich in fat and free

sugars,[1] but a deficiency of complex carbohydrate foods (the main source of dietary fibre)—have only become apparent over recent decades. Epidemiological research has demonstrated a close and consistent relationship between the establishment of this type of diet and the emergence of a range of chronic non-infectious diseases—including, particularly, coronary heart disease, cerebrovascular disease, various cancers, diabetes mellitus, gallstones, dental caries, gastrointestinal disorders, and various bone and joint diseases.

Scientific evidence continues to accumulate supporting the important role of diet in the development of the most common causes of premature death in developed countries: cardiovascular diseases and cancer. Excess intake of saturated fats and elevated levels of blood cholesterol are linked with coronary heart disease —the most prevalent cardiovascular disease in the developed world. The main risk factor for stroke—the leading cardiovascular disorder in many developing countries—is high blood pressure, in which obesity, alcohol intake, and excess salt intake play major contributory roles. Obesity is also strongly related to the onset of diabetes. It has been estimated that approximately one-third of cancers are associated with dietary factors. For example, an excess intake of fat has been linked to an increased incidence of cancers of the breast and colon.

The dynamic relationship between changes in a population's diet and changes in its health has been well reflected in the rapidly changing disease and mortality profiles of migrant populations moving from low-risk to high-risk countries (e.g., from Japan to the USA). It has also been evident in some countries, e.g., China, Mauritius, Singapore, and those in the Caribbean, that have undergone rapid development over the past 40–50 years.

This population-based evidence of the importance of diet has been amplified and confirmed by recent epidemiological studies in which information has been obtained from large numbers of individuals. The identity of the specific components of diet that increase the probability of occurrence of these diseases in individuals is being clarified. For some dietary risk factors, particularly in relation to cardiovascular diseases, there is recent epidemiological

[1] For the purposes of this report, the Study Group considered the term "free sugars" to include monosaccharides, disaccharides, and other short-chain sugars produced by refining carbohydrates.

evidence that a reduced consumption can lower the incidence of disease.

The causes of these chronic diseases are complex, and dietary factors are only part of the explanation. Individuals also differ in their susceptibility to the adverse health effects of specific dietary factors, but within the public health context the focus is the health of whole populations. Public health interventions aim to lower the *average* level of risk to health of whole populations, either because the whole population is at risk, or because a strategy to identify the minority of individuals at greatest risk, even if available, would only contribute to a modest public health improvement, since much if not most of the disease in the population occurs in the more numerous individuals at moderate to low risk.

1.3 The population perspective

Within any one population, the medical care system can sometimes develop approaches to reducing the risk of disease in certain individuals, particularly those at high risk. Thus, physicians may give dietary advice in order to lower the blood cholesterol level in a high-risk individual who has a strong family history of coronary heart disease or a raised blood cholesterol level.

From the clinical viewpoint, the health risk status of an individual is typically assessed by comparison with equivalent health risk measurements made on other members of the population. Thus, an individual's blood pressure or blood cholesterol concentration might be deemed to be "high" if, for example, it exceeds the levels present in three-quarters of the population. That is, the individual's health risks are viewed relative to those of other individuals in that population.

But from the population perspective, it may be that the entire population's risk profile is "high" relative to other populations. Thus, the public health approach to disease prevention requires health-oriented nutrition and food policies for whole populations. This has also been referred to as "mass intervention". For example, in developed countries populations with high average levels of blood cholesterol warrant food and nutrition policies (i.e., public health policies) directed at displacing that population's distribution of blood cholesterol levels to a lower range. Populations in developing countries, with their lower average levels of blood cholesterol,

should also adopt food and nutrition policies—but in their case the aim should be to avoid future increases in blood cholesterol levels.

This report is about primary prevention at the population level. In developing countries, the aim should be to avoid the diseases and premature deaths related to the "affluent" diet that characterizes the populations of many developed countries. In the developed countries, the aim should be to moderate or remove the excesses in the present diet that contribute to the high incidence of these diseases.

Developing countries can benefit by learning from the experience of dietary change and adverse health effects in many developed countries. If they act now, the governments of developing countries can gain for their people the health benefits of avoiding nutritional deficiencies without encouraging the development of the chronic diet-related diseases that usually accompany economic and technological development. Thus, as well as reduced childhood mortality, increased life expectancy should be sought by means of nutrition policies that minimize diet-related chronic disease, thereby avoiding the social and economic costs of premature death during the period of highest economic activity, in middle age. These nutritional policies will also improve the quality of life in the elderly.

1.4 Achieving population-based dietary change

If such a socially and economically desirable goal is to be achieved, then national governments in both developing and developed countries must:

1. Be aware of the relationship between the changes in a population's diet that tend to accompany economic development and the consequent changes in the health of the population.
2. Recognize that it is both possible and desirable to seek an optimum national diet, in association with economic development, that both maximizes health benefits and minimizes health hazards.
3. Develop nutrition-based health policies that are intersectoral. These should involve many government departments, and be supported by the activities of nongovernmental organizations, health care workers, and the community at large. Such widespread involvement is needed in order to influence favourably the production, processing, and marketing of foods conducive to health, and to increase public awareness of the

relationship between food and health. The mix of integrated policies will constitute a progressive, health-oriented, national food and nutrition policy. From the individual's point of view, such a policy will make healthy choices when purchasing food the easy choices.

Intersectoral public policies are difficult to develop. The links between diet, nutrition, and health have often been poorly specified, and it has therefore been difficult to bring the issues into focus as a coherent public policy. The priority traditionally given in national budgets to food production, without regard to the effects on the consumers' nutrition and health, needs to be reconsidered. Short-term policies that seek to maximize local economic activity and foreign exchange earnings, while neglecting health considerations, may incur substantial health care costs and loss of productivity in economically important groups of the community.

Economic development is normally accompanied by improvements in a country's food supply as regards both quantity and quality (i.e., less spoilage and less contamination of food). Provision of a nutritionally adequate and hygienic diet, in a socially equitable fashion, confers major health benefits, including:

- Elimination of dietary deficiency diseases.
- Reduction of acute and chronic foodborne diseases.
- Improvements in overall nutritional status, including increased childhood growth rates.
- Increased resistance to bacterial and parasitic infectious diseases.

A major consequence of improvements in the food supply has been an increase in life expectancy. However, further economic development has entailed qualitative changes in the production, processing, distribution, and marketing of food. With these changes have come the problems of diet-related chronic diseases, which typically occur in middle and later adult life, and counteract the gains in life expectancy attributable to an improved food supply. These chronic diseases are, in part, manifestations of nutrient excesses and imbalances in the "affluent" diet, so they are in principle largely preventable.

In developed countries, the enormous cost of the high-technology, tertiary health care needed for the diagnosis and management of these high-incidence chronic diseases is already apparent. Similar demands in developing countries will impose a

huge burden on the human and economic resources of the country and are liable to disturb priorities in the health care sector.

In many developed countries, there is now growing evidence of social and political acceptance of the need for prevention-oriented health policies and behaviour to reduce the incidence of diet-related chronic diseases. Some developed countries have been active in public education, using national dietary guidelines as a stimulus. Changes in consumer preferences (e.g., for foods lower in salt, free sugars, and saturated fat, but higher in dietary fibre) have emerged, initially in the upper socioeconomic groups. These changes in preference are leading to modification of systems for food production and processing. Progress in changing consumer preferences is intrinsically slow, and so far has occurred largely without any support from public policies in any but the health sectors.

Despite this limited support, mortality from coronary heart disease (the leading cause of death in developed countries) has begun to decline and there has been a reduction in the prevalence of hypertension in many developed countries. The downturns have been particularly strong—with, for example, a fall of 40–50% in deaths due to coronary heart disease over the past 20 years in North America and Australia. These recent reductions in death rate reflect changes in population life-style, e.g., in dietary habits, such as decreases in the consumption of saturated fats.

The process of changing unsatisfactory dietary practices and promoting health in developed countries can prove socially and politically difficult. Similarly, there will be difficulties in developing countries, even if action is needed to avoid dangerous trends rather than to reverse them. Inappropriate public perceptions in developing countries of what constitutes a better diet, and the economic pressures to establish local food industries based on products with high contents of fat, sugar, and salt, are already evident. These issues must be confronted and dealt with if the suffering and economic impact of cardiovascular diseases, cancers, and other diet-related chronic diseases are to be avoided.

In some developing countries, the first priority must remain the attainment of an adequate food supply for the whole population and the elimination of various forms of nutritional deficiency among vulnerable groups (e.g., protein–energy, vitamin, and mineral deficiencies). However, as in the developed countries, efforts are also required to forestall or arrest a population shift towards a high

intake of saturated fat, sugar, and salt. This shift is now occurring almost everywhere, even if only in some sectors of society. The challenge is therefore to know how best to formulate health-oriented national policies for food that can provide the usual health gains associated with economic development while minimizing the future social and economic costs of the diet-related chronic diseases of adult life that will emerge if developing countries follow the previous experience of many countries in the developed world.

2. CHANGES IN PATTERNS OF DISEASE IN RELATION TO CHANGES IN DIET

This section summarizes the long-standing health problems caused by nutritional deficiencies. It then explores the widespread emergence of the more "affluent" type of diet that has accompanied economic development and urbanization and is associated with an increase in the incidence of many chronic diet-related diseases of adult life.

2.1 Deficiency diseases

2.1.1 *Protein–energy malnutrition*

Undernutrition, malnutrition, and the widespread prevalence of communicable diseases have been the major health and welfare problems facing developing countries for the last 50 years. After the Second World War, medical research revealed a host of nutritional disorders in many developing countries, e.g., pellagra, and vitamin A- and iodine-deficiency states. Protein–energy malnutrition was recognized as a widespread and important public health problem in all regions of the developing world. Methods of defining protein–energy malnutrition in children and adults were developed for use in both a clinical and a public health context. The growth of children and the size of adults reflect the effects of diet, infection, psychosocial and genetic factors, and, indirectly, agricultural and economic influences. Anthropometric measures are therefore one index of the nutritional state of the individual or community.

More recently, it has become clear that the resistance of children and adults to infectious diseases often depends on their nutritional state, which can have a profound impact on the development of

immunity. Given this perspective, and the rapidly expanding populations of many developing countries, economic planning for the health services and for agriculture has properly emphasized the importance of a clean water supply and environmental improvements to reduce waterborne parasitic and enteric infections; childhood immunization programmes; a hygienic and nutritionally adequate diet to prevent malnutrition, deficiency diseases, foodborne infections, and intoxication; and the equitable distribution of resources within the population.

Once water quality and food sufficiency and safety have been addressed at national level, economic planning comes to be dominated by considerations other than health issues. Hence, many governments now emphasize the importance of improving the economic welfare of subsistence farmers who, in a number of developing countries, constitute the majority of the population. Import/export policies, agrarian reform, food subsidies, rural development schemes, and, more recently, economic structural adjustments usually dominate the making of economic and agricultural policies at both national and international levels.

Over the last 20 years, substantial progress has been made in making food available (Table 1) and in improving health, although the sub-Saharan region of Africa remains of extreme concern in relation to food supplies (Table 2). In Africa, there is a clear concordance between the FAO estimates of national food availability in 1979–1981 (Table 2) and the prevalence of underweight children in each country. More recently collated anthropometric data for children in different African countries confirm these relationships.

The extremely difficult economic, agricultural, and health circumstances of sub-Saharan Africa should not obscure the dramatic changes in the health status of many of the urban communities in the region, and the major advances in agriculture and health care made in the rest of the world. In these other regions there has been, despite a huge increase in population, a rise in per caput food production. Indices of general nutritional status, as well as of health care, have also shown substantial improvements, with progressive declines in the proportion of low-birth-weight babies and of wasted children, and in infant and child mortality.

Over the last 25 years, China's food production has increased substantially and its population by about 60%; dietary energy supply increased from less than 1800 $kcal_{th}$ (7.53 MJ) per caput per

Table 1. Trends in per caput dietary energy supplies, by region and economic group[a]

Region	Period A 1961–63 ($kcal_{th}$ per caput per day)	Period B 1981–83 ($kcal_{th}$ per caput per day)	% increase A–B
Developed countries	3110	3390	9
Developing countries	1980	2400	21
Developing market economies	2060	2340	14
—Africa	2120	2230	5
—"Far East"[b]	1940	2190	13
—Latin America	2370	2620	11
—"Near East"[b]	2230	2900	30
Asian centrally planned economies	1830	2540	39
World	2340	2660	14

[a] Adapted from reference *1*, by kind permission of the Food and Agriculture Organization of the United Nations.
[b] As defined by FAO, see reference *1*.

Table 2. Daily per caput dietary energy supplies for the 20 most populous countries in Africa south of the Sahara, 1979–81[a]

<2000 $kcal_{th}$	Burkina Faso Ghana Mali Mozambique Uganda
2001–2300 $kcal_{th}$	Cameroon Ethiopia Kenya Malawi Zaire Zambia Zimbabwe
>2300 $kcal_{th}$	Angola Côte d'Ivoire Madagascar Nigeria Senegal South Africa Sudan United Republic of Tanzania

[a] Adapted from reference *1*, by kind permission of the Food and Agriculture Organization of the United Nations.

day in 1961–63 to 2560 $kcal_{th}$ (10.71 MJ) in 1983–85. There were corresponding increases in birth weights and childhood growth rates, and infant mortality fell from 200 (per 1000 live births) before 1949 to about 40 in 1980, and to 35 in 1982. Improvements in sanitation, health care, the control of communicable diseases, and diet account for this reduction in mortality.

In many regions, e.g., southern Asia, South America, and northern Africa, infant mortality is still high, but in most countries it continues to decline. Trends in anthropometric data for children under five years of age indicate that the prevalence of wasting (i.e., the proportion of children less than two standard deviations below the reference weight-for-height) and of low birth weight (the proportion of infants weighing less than 2500 g at birth) has decreased significantly in the last two decades. In the WHO regions of the Americas, Eastern Mediterranean, Europe, and Western Pacific, many national averages for wasting and low birth weight are below 8%. In parts of southern Asia and Africa, wasting is still a major public health problem, and national averages also hide the existence of differences and inequalities among various socio-economic groups within the same country.

Growth failure (stunting) remains widespread in most of the developing world. Although the overall trends indicate an improvement in growth, the average rates of growth in childhood may be decreasing in some African countries. The decrease in the proportion of wasted and stunted children has unfortunately been outweighed by large increases in the total populations of South-East Asia and Africa, so that the net result has been an increase in the total number of wasted and stunted children in Africa, and no change in Asia.

While acute childhood malnutrition is, in general, a receding problem, large populations of children and adults, especially in Africa, are nevertheless subsisting on inadequate food supplies in times of drought.

There is also widespread chronic undernutrition around the world, causing growth retardation among children and affecting physical and psychosocial development, as described later (section 4.1.1). Continuous surveillance and appropriate interventions are needed in many countries, particularly in areas affected by natural and man-made crises and by economic recession.

Many epidemiological studies have linked a low intake of animal protein to high childhood mortality, morbidity, and growth failure. For many years, this evidence was interpreted as meaning that the amino acids present in animal protein were necessary to complement the amino acids in plant foods. (Most animal sources contain the complete range of essential amino acids, while many plant sources are low in one or more.) Progressively it was recognized that, even in totally vegetarian diets containing a diversity of foods, plant

sources tended to complement one another in amino acid supply. Although the total amount of protein in the diet may need to be higher in vegetarian diets to provide an adequate intake of all the amino acids, the usual concentrations of proteins in these diets are sufficient. If the energy needs of the child or adult are met by these diets—then so are the amino acid needs. With this evolution of understanding, a reconsideration of the epidemiological data suggested that the apparent "animal protein effect" on childhood growth and health was not necessarily a biological effect related to protein supply as such. Animal protein consumption might instead be serving as an index of more affluent household conditions that affected both buying power and living conditions. Alternatively, animal food sources may be improving health by counteracting micronutrient deficiencies. There is strong evidence that, as income constraints are relieved in most developing societies, there is a spontaneous demand for increased intakes of foods of animal origin. Studies continue to show a positive association between intake of such foods and a range of improved functions (physical and psychological) among the deprived segments of many populations. However, it has not been shown scientifically that increasing the consumption of such foods will, in itself, improve these human functions.

It should be recognized that, at some stages of life, there continue to be strong nutritional reasons for advocating at least modest intakes of foods of animal origin. Even more importantly, the risk of deficiencies of protein and other nutrients may increase as the range of different foods in individual diets becomes more limited. Diversity in the availability and use of foods must therefore continue to be a key component of any programme aimed at maintaining, or improving, the nutritional health of the population. A policy to limit the consumption of saturated fatty acids should not be simplified to signify a need to limit foods of animal origin whatever their fat content.

In agrarian societies it is now clear that consideration must be given not only to the supply of food and nutrients but also to the short- and long-term effects of agricultural policies upon the income and buying power of the small producers. In turn, as urban migration proceeds, policies must be adjusted to take account of the differential impact on an urban cash economy and on a rural subsistence economy of agricultural and dietary changes. There is a

need to strive for equity in both population groups, while ensuring a nutritionally adequate and appropriate diet.

2.1.2 *Iodine deficiency disorders*

Iodine deficiency disorders are a major scourge and their prevention or amelioration depends on the ready availability of iodine in the water consumed by the population, or in the types of food eaten. The Andes, Alps, Great Lakes basin of North America, and the Himalayas are particularly iodine-deficient mountainous areas, but coastal areas and plains may also be deficient. Excessive intakes of goitrogens (for example from consumption of cassava in central Africa, or of waterborne goitrogens in Latin America) interfere with the normal uptake and metabolism of iodine and can thus amplify the effects of iodine deficiency.

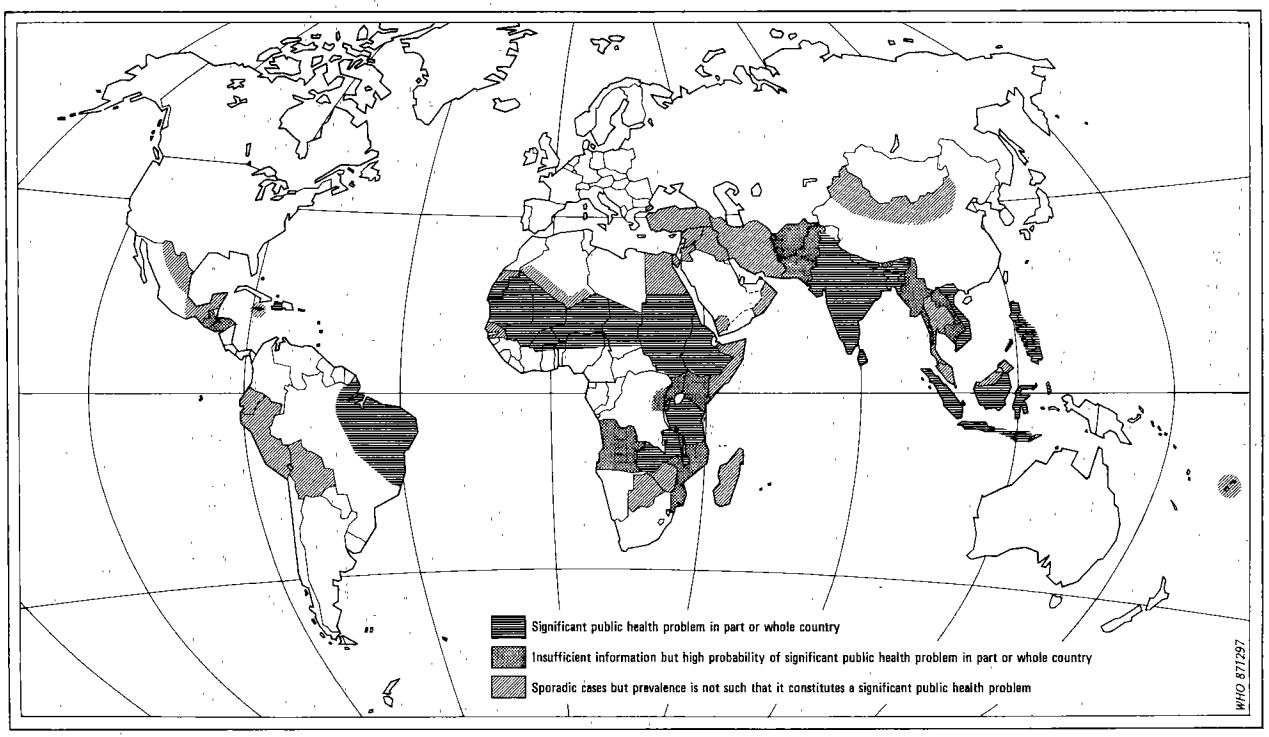
In addition to the clinically obvious and easily recognizable effects of iodine deficiency (i.e., goitre and cretinism), the more pervasive effects of milder iodine deficiency on the survival and physical and mental development of children, intellectual ability, and the work capacity of adults are now being recognized. Iodine deficiency disorders (*2*) are of sufficient importance to warrant urgent government action and monitoring, since about one thousand million people are affected in more than 80 countries.

Elsewhere in this report, recommendations are made that if adopted would lead, for many countries, to reduced salt consumption. Iodination of salt is one of the very few effective ways of controlling endemic goitre, and indeed there is some indication that the problem is increasing in some sections of Europe as people voluntarily reduce salt usage. In areas where iodine intakes from other sources are low, there is a clear need for coordination of policies relating to the control of goitre by iodination of salt and to the control of hypertension risk by limiting salt intake. There may be a need to adjust the iodination levels of salt as salt intake changes or, in industrialized countries, to add iodine to all salt rather than only to table salt.

2.1.3 *Vitamin A deficiency*

Vitamin A deficiency, leading to xerophthalmia and sometimes blindness, continues to be a widespread problem among children (Fig. 1). Deficiency of vitamin A also decreases resistance to

Fig. 1. The geographical distribution of xerophthalmia in 1987[a]



[a] Adapted and updated from reference *3*, by kind permission of the International Pediatric Association.

infections and increases mortality. There is now some evidence that vitamin A supplements in deficient populations can reduce both mortality and blindness. Analyses of food supplies from different regions show that the availability of vitamin A is limited; this problem is exacerbated by any tendency to withhold vegetables from children for cultural or other reasons. In Asia, there is a particular problem because the estimated overall average availability of vitamin A is less than that required by the population. Any maldistribution of foods high in vitamin A within the population would further exacerbate the problem. Although in most countries there is a slow but steady improvement in the availability of foods rich in vitamin A (Fig. 2), xerophthalmia continues to be a major problem in about 40 countries.

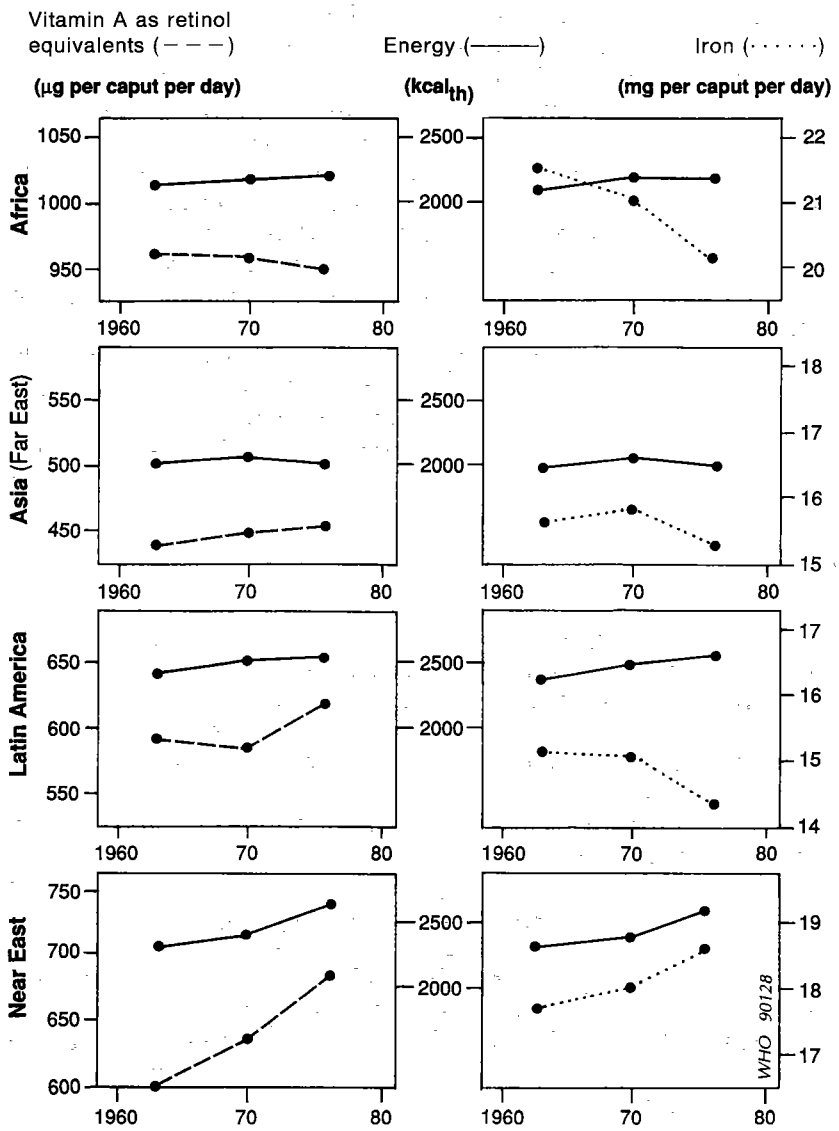
Elsewhere in this report, emphasis is placed upon the desirability of low-fat diets for the prevention of cardiovascular disease and cancer. Very low fat intakes will interfere with the absorption of vitamin A and provitamin A. However, at the levels of fat advocated in this report, i.e., 15–30% of energy, no detrimental effects on absorption would be expected.

2.1.4 *Iron deficiency*

A further example of a continuing deficiency disease of widespread importance is anaemia. Table 3 shows the startling difference in the prevalence of anaemia at all ages in developing compared with developed countries. Africa and southern Asia have a particular problem, the dominant cause being iron deficiency. Intestinal parasitosis exacerbates iron deficiency by increasing the loss of blood from the intestine. This loss, in association with a low intake of iron and/or its poor absorption, can lead to profound anaemia, which impairs the intellectual development of children and limits both children's and adults' capacity for physical activity. In Africa, Asia, and South America, the trend in iron availability has been deteriorating rather than improving (Fig. 2), so it is not surprising that iron deficiency anaemia continues to be a massive public health problem in the world. There is also some evidence of anaemia occurring among young children, pregnant women, and the elderly in industrialized countries.

The availability of dietary iron for absorption is affected by both the form of iron and the nature of the foods concurrently ingested. Two major forms of iron exist in diets—haem iron and "inorganic"

Fig. 2. Changes in availability of vitamin A, iron, and energy, by FAO region, from 1960/65 to 1975/77[a]



[a]Reproduced with permission from reference *4*. Far East and Near East as defined by FAO, see reference *1*.

Table 3. Estimated prevalence of anaemia and number affected, by geographical region and age/sex category, around 1980 (population data in millions)[a, b]

Region	Children				Men 15–59 years		Women 15–49 years			
	0–4 years		5–12 years				Pregnant		All women	
	%	No.	%	No.	%	No.	%	No.	%	No.
Africa	56	48.0	49	47.3	20	23.4	63	11.3	44	46.8
North America	8	1.6	13	3.6	4	3.1	–	–	8	5.1
Latin America	26	13.7	26	18.1	13	12.8	30	3.0	17	14.7
Eastern Asia[c]	20	3.2	22	5.6	11	6.1	20	0.5	18	8.4
Southern Asia	56	118.7	50	139.2	32	123.6	65	27.1	58	191.0
Europe	14	4.7	5	2.7	2	3.0	14	0.8	12	14.1
Oceania	18	0.4	15	0.5	7	0.5	25	0.1	19	1.0
Developed regions	12	10.3	7	9.1	3	12.0	14	2.0	11	32.7
Developing regions	51	183.2	46	208.3	26	162.2	59	41.9	47	255.7
World	43	193.5	37	217.4	18	174.2	51	43.9	35	288.4

[a] Adapted from reference *5*.
[b] Anaemia is defined as a haemoglobin concentration below WHO reference values for age, sex, and pregnancy status (see WHO Technical Report Series, No. 405, 1968).
[c] Excluding China.

iron. The former, found only in animal sources, is readily available and absorption is not influenced by other constituents of the diet. Absorption of inorganic iron is strongly influenced by factors present in foods ingested at the same time. Two widely recognized promoters of absorption are animal foods and ascorbic acid (vitamin C). Even though diets based primarily on cereals and legumes may contain much iron, without coexistent factors such as vitamin C, they may actually provide only a low level of available iron (*6*).

Concern about iron deficiency is one nutritional reason for recommending the consumption of at least some meat, or foods providing a substantial amount of ascorbic acid.

2.1.5 *Fluoride deficiency*

There is clear clinical, epidemiological, and experimental evidence that fluoride significantly reduces the incidence of dental caries (*7*). Until about 10 years ago it was believed that fluorides worked principally by increasing the resistance of enamel to acids produced in dental plaque from sugars. More recent research clearly shows that fluoride acts principally by remineralizing the early carious lesion and by an effect on the bacteria in dental plaque. Fluoride

intake may be increased to optimum levels by fluoridation of community water supplies, by adding fluoride to salt, milk, or toothpaste, by taking fluoride supplements, or by the topical application of fluoride.

The combined effect of fluoride sufficiency and a lowered intake of free sugars (including sucrose) is beneficial in terms of the development of caries (see section 3.8). The consumption of a limited amount of free sugars is acceptable only if the population is using fluoridated toothpaste and/or drinking fluoridated water.

2.1.6 *Vitamin B_{12} deficiency*

Vitamin B_{12} deficiency causes anaemia and, if severe, neurological disorders. It is of concern with vegetarian diets containing no animal foods. Vitamin B_{12} is a product of bacterial fermentation, such as occurs in the intestine of ruminant animals such as cattle, sheep, and goats. Meat and milk are major sources of vitamin B_{12}. Some may be contributed also by fermented foods. The need for vitamin B_{12} has therefore been a part of the rationale for recommending the consumption of animal foods. The levels of animal foods recommended in this report would be ample to supply the dietary needs for this vitamin (*6*).

Pernicious anaemia, a severe vitamin B_{12} deficiency secondary to a defect in the absorption of vitamin B_{12}, occurs with low incidence in all societies, and is unaffected by the dietary level of vitamin B_{12}, or the nature of the diet.

2.1.7 *Other nutrient deficiencies and excesses*

Only the major deficiencies have been mentioned above. Other significant disorders include:

1. Rickets, which is still widespread in parts of northern Africa and the eastern Mediterranean, and is reported to be increasing in Mexico; this condition is attributable to insufficient exposure to sunlight and lack of vitamin D in the diet.
2. Ascorbic acid deficiency, particularly in some drought-affected populations, e.g., in Africa.
3. Deficiencies of other trace elements, e.g., of zinc.

4. Excessive intakes of certain vitamins and minerals (e.g., vitamin A/carotene, vitamin D, selenium, and fluorine), which can occur as a result of prolonged or acute overdosage, usually in affluent countries. The subject of fluorosis is discussed elsewhere (section 3.8).

2.1.8 *Conclusion on the importance of deficiencies*

While in most parts of the world there have been significant advances in the control of protein–energy deficiency and specific nutritional disorders, in all regions of the world there are still some populations affected by one or more of these deficiencies. In some regions, the number of undernourished people is increasing even if the proportion is declining. Even the trends in prevalence are unfavourable in some countries. While the emphasis in this report is on preventing the diseases related to overnutrition or to excesses of certain elements in the diet, for the majority of countries there is still a need for vigorous policies and action to combat the various deficiency disorders, as part of comprehensive health-oriented national food and nutrition policies. Improvement is needed in the quality as well as the quantity of the diet, but greater quantities of food are particularly important in sub-Saharan Africa and southern Asia.

As a guide for policy-makers, recommended dietary intakes for energy, vitamins, and minerals to avoid deficiencies are given in Annex 1.

2.2 Emerging diet-related chronic diseases

While some developing countries remain concerned with the problems of hunger and malnutrition, and communicable diseases, in other countries there have been considerable increases in the prevalence of chronic diseases. For example, during the 1970s, mortality from these diseases underwent a relative increase of 105% in tropical South America and 56% in Central America, Mexico, and Panama (Table 4). Similar increases in these diseases are occurring in developing countries in all regions of the world.

Rapid changes are occurring in the life-styles and the dietary and health patterns of the populations in developing countries. There has been a huge increase in the numbers of people moving from rural to

Table 4. Changes in the percentage of total mortality due to chronic diseases in five subregions of the Americas between 1970 and 1980[a]

Subregion	Percentage mortality attributed to chronic diseases (1980)	Relative % increase (1970–1980)
North America (USA and Canada)	75	0.4
Temperate South America (Southern Cone countries)	60	11
Caribbean area	57	21
Tropical South America	45	105
Continental Middle America (Central America, Mexico and Panama)	28	56

[a] Adapted from reference *8*.

urban communities, where striking changes in diet often occur (see section 2.2.1).

Table 5 shows that obesity in adults is not confined to the industrialized countries. Obesity is already prevalent in the developing world, particularly in women, with very high rates in some places, e.g., in Trinidad. The prevalence of obesity is surprisingly variable, but in some developing countries high rates are already evident in children as well as in adults (Fig. 3). As life expectancy increases in many developing countries, new problems of cardiovascular disorders and cancers are emerging; these reflect the coexisting effects of the demographic "aging" of the population and of newly acquired risks relating to the diets and life-styles that have accompanied economic development. On current trends, such diseases will present a huge health-care burden for less affluent communities in the near future.

The stage at which cardiovascular disease emerges as a significant cause of death corresponds to a life-expectancy level between 50 and 60 years, and at this level cardiovascular disease mortality accounts for 15–25% of all deaths. This analysis reflects cross-sectional data from different countries, but the pattern has been confirmed by longitudinal studies of the evolving pattern of disease and life expectancy in many developed as well as developing societies. Cardiovascular diseases were on average already becoming a significant cause of death in developing countries between 1970 and 1975, whereas the corresponding period in the USA was about 50 years earlier, i.e., in the 1920s. On current projections, cardiovascular diseases will emerge or be established as a substantial health problem in virtually every country in the world by the year 2000.

Table 5. Prevalence of obesity in adults in national surveys as indicated by a body-mass index (BMI) greater than 30[a, b]

Country or area	Age group (years)	Percentage obese	
		Male	Female
Costa Rica	40–45	5.7	14.4
El Salvador	40–45	0.0	1.5
Guatemala	40–45	0.0	5.6
Honduras	40–45	2.8	6.0
Nicaragua	40–45	3.1	16.4
Panama	40–45	2.3	1.7
Trinidad (urban)	40	–	32.0
Australia	35–44	6.2	7.5
Canada	–	8.5	9.3
Netherlands	35–49	4.2	5.0
United Kingdom	35–49	7.9	8.6
United States of America	–	12.0	15.0

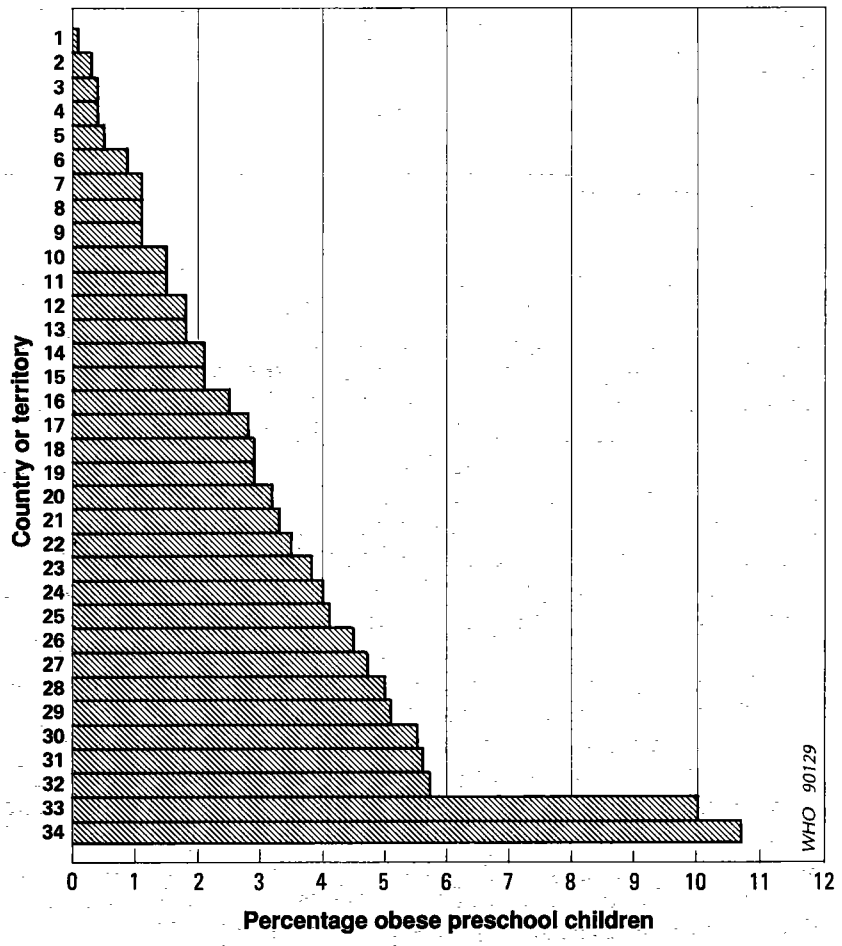
[a] Adapted from reference *9*.
[b] BMI = body mass in kg/(height in metres)^2.

Good data from Africa are limited, but Mauritius has experienced a 65% increase in death rates from both coronary heart disease and breast cancer over the last 30 years. These diseases are already becoming a burden on hospitals in the capitals of the sub-Saharan countries, where they particularly affect the middle classes. These affluent groups have already changed their diets from the traditional foods and increased their smoking. In several Asian, Caribbean, and Latin American countries, the problem of breast cancer is evident, and although there is variation from country to country, the emergence of coronary heart disease is also apparent. In some countries, divergent trends have occurred. For example, in Japan, the incidence of breast cancer is increasing as diets change, but the reduction in hypertension seems to have overridden the effect of an increasing intake of saturated fat, such that Japanese national rates for coronary heart disease have been falling.

Population surveys carried out since 1970 in developing countries show that the prevalence of hypertension ranges from 1% to 30% in some African countries to over 30% in Brazil (*10*, *11*). In many Latin American countries, death rates from hypertensive disease and stroke are declining, changes also ascribed to the effects of dietary alterations. The prevalence of hypertension is low in rural areas of developing countries, where the diet is low in salt.

Table 6 shows the estimated life expectancy of individuals in countries from the different regions in the 1950s and 1980s, and the changes projected for the years 2020–2025. Every region of the world

Fig. 3. Prevalence of obesity in preschool children, defined as a weight more than two standard deviations above the reference median weight-for-height[a, b]



See facing page for explanatory notes.

Country or area	Notes[c]
1. Papua New Guinea	Kar Kar, Lufa
2. Bangladesh	Rural
3. Philippines	
4. Burkina Faso	Mossi Tribe
5. Singapore	
6. Togo	Gourma Tribe
7. Tunisia	1–4.99 years
8. Rwanda	
9. India	Kerala
10. Indonesia	East Java
11. Belize	
12. Jordan	Amman (rural)
13. Tahiti	
14. Nicaragua	
15. Brazil	Paraiba
16. Saint Lucia	
17. United Kingdom	
18. Yugoslavia	Zagorje (rural)
19. Antigua	
20. Zambia	
21. Venezuela	
22. Italy	1–4.99 years
23. Panama	
24. Peru	
25. Barbados	
26. Honduras	Suyapa, 0–2.99 years
27. Lesotho	
28. Bolivia	Montero Region
29. Trinidad and Tobago	
30. Iran (Islamic Republic of)	Rural
31. Mauritius	
32. Canada	
33. Jamaica	
34. Chile	0–5.99 years

[a]Reproduced from reference *9*.
[b]Reference population of the National Center for Health Statistics, USA.
[c]Children aged 0–59 months unless otherwise stated.

has seen an increase in life expectancy over the last 30 years, and this is expected to increase markedly in Africa and Asia over the next 30 years.

As infant and childhood mortality declines, the proportion, and total numbers, of people living into old age can be expected to increase rapidly. Table 7 shows the projected increase in the numbers of elderly, aged 60 years and over, by the year 2025. A substantial increase in numbers is expected even in Africa and Asia, where the expected age structure will still be dominated by children and young adults. Asia and Latin America will have a proportion of elderly in 2025 that exceeds the proportion observed in the more affluent communities in the 1950s.

Thus, it can be predicted that in all regions of the world there will be many millions of older adults who, although immune to many

infections, will be susceptible to cardiovascular diseases and cancers. Table 8 shows the causes of death in the developed and developing world in 1980. Clearly, infectious and parasitic diseases are still of immense significance in the developing world, but cardiovascular diseases and cancer already account for over a fifth of all deaths. If deaths in infancy and childhood are excluded, then these chronic diseases assume much greater significance.

Table 6. Trends in life expectancy at birth, for different regions (both sexes combined)[a, b]

Region	1950–1955	1980–1985	2020–2025
Northern America	69.0	74.6	79.7
Europe	65.3	73.2	79.1
Oceania	60.8	68.0	75.6
USSR	64.1	67.9	76.7
Latin America	51.2	64.5	72.8
Asia	41.1	59.3	72.8
Africa	38.0	49.9	65.2
Developed countries	65.7	72.3	78.7
Developing countries	41.0	57.6	70.4
World total	45.9	59.6	71.3

[a] In years, medium variant used for projection.
[b] Adapted from *World Population Prospects, 1988* (United Nations publication, Sales No. E.88.XIII.7), reference *12*, by kind permission of the publisher.

Table 7. Elderly population, aged 60 years or more, in millions by region (1950, 1985, and projections for 2025)[a]

Region	Total population 1985	Elderly population					
		1950		1985		2025[b]	
		No.	%	No.	%	No.	%
Europe	492	51	12.9	88	17.8	138	27.0
Northern America	265	20	12.1	43	16.4	88	26.4
USSR	277	16	9.0	37	13.5	72	20.6
Oceania	25	1	11.3	3	12.3	7	18.5
Asia	2834	92	6.7	205	7.2	698	14.3
Latin America	404	9	5.3	27	6.8	97	12.7
Africa	557	12	5.4	27	4.9	101	6.4
Developed countries	1174	95	11.4	189	16.1	343	25.3
Developing countries	3680	106	6.3	243	6.6	858	12.1
World total	4854	201	8.0	432	8.9	1201	14.8

[a] Adapted from *World Population Prospects, 1988* (United Nations publication, Sales No. E.88.XIII.7), reference *12*, by kind permission of the publisher.
[b] Medium variant used for projection.

Table 8. Causes of death in 1980 in developed and developing countries, and world total[a]

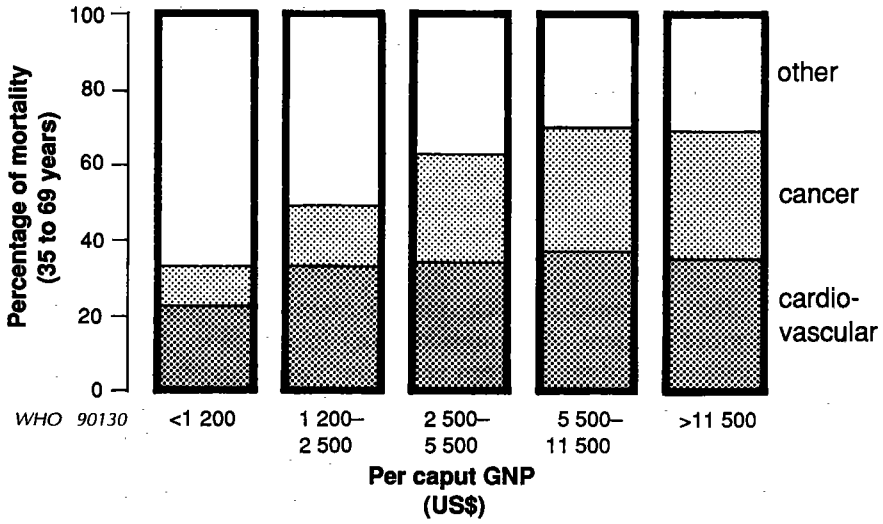
Causes of death	Percentage of deaths		
	Developed countries	Developing countries	World total
Diseases of the circulatory system	54	19	26
Neoplasms	19	5	8
Infectious and parasitic diseases	8	40	33
Injury and poisoning	6	5	5
Perinatal mortality	2	8	6
All other causes	12	23	21

[a] Adapted from reference *13*.

It is often assumed that chronic diseases develop as countries become more affluent. Although striking increases in deaths from these causes are evident between very poor countries and those with an average gross national product (GNP) of US$ 2000, the age-adjusted mortality of men and women aged 35–69 years of age, i.e., in an age span of potential economic activity, is dominated by cardiovascular disease and cancers in countries with a modest as well as a high GNP (Fig. 4). In countries with a GNP of US$ 3000–4000, the burden of cardiovascular disease and cancers is nearly as great as in the very affluent countries with an average income three times greater. Thus, modest increases in prosperity in populations with low GNP seem to be associated with the most marked increases in the proportion of these chronic diseases, which pose a major long-term burden on the health services of a country.

The link between increased economic development and the increased rates of cardiovascular diseases and cancers in the population is mediated by the acquisition of certain life-style characteristics. The changes in disease pattern are therefore not inevitable. Fig. 5 shows how the principal components of the diet tend to be related to a nation's relative affluence. As GNP increases, there is a progressive substitution of dietary fat from animal sources for complex carbohydrates. Free sugars, especially sucrose and glucose syrups, also form a much higher proportion of the total dietary carbohydrates in very affluent communities, e.g., 50% compared with the 5–10% observed in many communities with a low income. Thus, variation in the consumption of starchy foods and animal fats is the most striking feature of the different dietary patterns of societies with different degrees of affluence.

Fig. 4. Proportion of deaths from cardiovascular diseases, cancer, and other diseases, for both sexes aged 35–69, in relation to per caput gross national product[a]

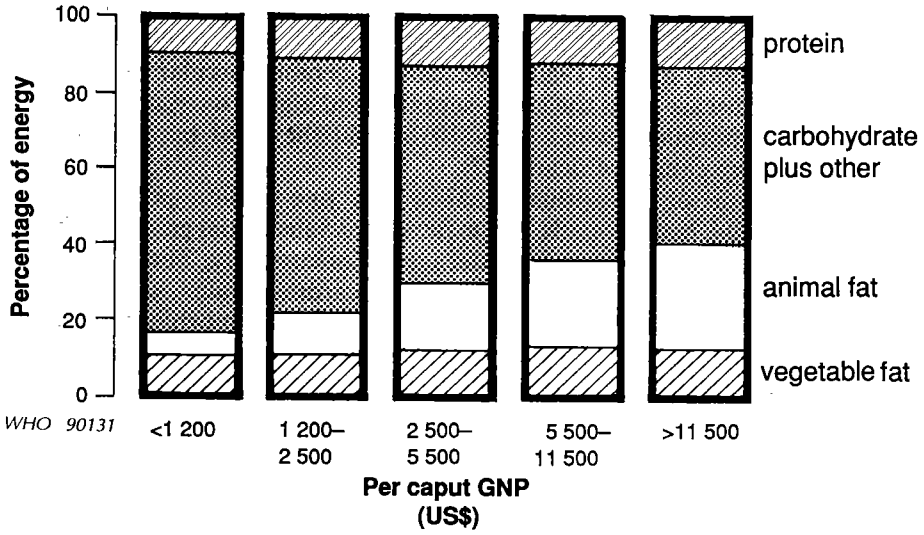


[a] This diagram is based on an analysis of cause-specific mortality rates for the ages 35–69 years, from the WHO international mortality data base, adjusted to the world population, standard-age distribution. Fifty-two countries satisfied selection criteria for this analysis: information was available on national mortality by age group and on per capita gross national product (GNP), and the population numbered more than one million. Countries were divided into five groups according to GNP. Information on GNP was obtained from The World Bank (*14*).

Burkitt & Trowell (*16*), after reviewing the descriptive epidemiological data from many developing and developed countries, concluded that there is usually a sequence in the emergence of chronic disease as the diet of the developing country becomes more "westernized". Appendicitis and diabetes tend to occur early, followed after several decades by coronary heart disease and gallstones, then cancer of the large bowel, and finally various chronic disorders of the gastrointestinal tract.

Such changes have occurred more obviously in countries or population groups undergoing rapid transition between different cultural stages. For example, the Australian Aborigines traditionally derived most of their diet from roots and vegetables that contained much fibre. During the first half of the 20th century, white flour and sugar became their predominant sources of dietary carbohydrate, and this change, together with a sedentary life-style, was linked to

Fig. 5. Components of diet in relation to per caput gross national product[a]



[a]This diagram is based on an analysis of diet components, GNP, and mortality rates. Fifty-two countries satisfied selection criteria for this analysis: information was available on per capita gross national product (GNP) and on energy and fat consumption, and the population numbered more than one million. Information on diet components was obtained from FAO (*15*), and on GNP from The World Bank (*14*).

the emergence of high rates of obesity and diabetes, followed by hypertension and coronary heart disease.

American Indians in the USA, who formerly consumed maize (corn) in large quantities, have experienced gross obesity and diabetes since changing their main sources of dietary carbohydrate to white flour and sugar. Now, more than 50% of Pima Indians over 35 years of age have diabetes. The dietary transition, and the associated obesity, appear to be important causes of the diabetes; however, other life-style changes, including reduced physical activity and increased stress, are possible contributors. Similarly, in the South Pacific Island of Nauru, 70% of people over the age of 50 years have diabetes. This change, which followed the rapid introduction of a cash income with a sedentary life-style, has produced a dramatic change in health.

The dietary staple in southern China has been rice for many centuries; in the north the main staple is corn or wheat. Traditionally, fat and sugar consumption has been low and animal protein consumption especially low. However, the diet is gradually

changing in the cities to resemble that of the more affluent countries, and this has been associated with the appearance of significant coronary heart disease and diabetes. For example, in Shanghai County, China, during 1960–1962, cancer, cerebrovascular disease, and heart disease were the sixth, seventh, and eighth most common causes of mortality, whereas by 1978–1980 they had become the three leading causes of death (*17*).

The island of Mauritius, inhabited by one million people of various ethnic backgrounds, has experienced substantial gains in life expectancy over the past four decades. Concurrently, new health problems have emerged, and today cardiovascular diseases, diabetes, and cancers are the leading causes of morbidity and mortality. Deaths from cardiovascular diseases accounted for about 2% of all deaths in the early 1940s, and for about 45% of deaths in the 1980s. Age-standardized death rates, since 1960, have doubled for coronary heart disease, have remained high for stroke (in contrast to decreases in most other countries of the world), and have trebled for cancer of the breast in women.

Among the developing countries, Mauritius is frequently cited as an example of a country in which economic and social transition has occurred unusually rapidly. The emergence of chronic degenerative diseases associated with this transition has had serious implications for the direct costs to the health sector and, indirectly, to the national economy. The national government has, therefore, recently committed itself to a programme of developing "primordial",[1] primary, and secondary prevention strategies for the prevention and control of these recently acquired, diet-related diseases.

2.2.1 *Urbanization, changing diet, and chronic diseases in developing countries*

A striking change in developing countries has been the rapid increase in the proportion of people living in urban areas. This has had an immediate impact on the nature of the food supply, because no longer is a household relying on the ready availability of home-grown produce or on its storage within the household. The cash economy is of far greater significance for the urban household's food supply, and expanding urban communities place great demands on the transport and storage systems for food. Food preservation

[1] A primordial prevention strategy aims at preventing the emergence of predisposing conditions in communities in which they have not yet appeared.

therefore becomes of even greater significance than in the rural areas, and the availability of large numbers of people within a confined area provides a ready market for the development of small and medium-sized food industries. These developments are often encouraged by government subsidies, tax incentives, or administrative support as governments seek to solve the problem of both urban unemployment and food supply.

Not surprisingly, therefore, analyses of the dietary patterns of urban and rural dwellers in the same country show striking differences. There is an almost universal increase in fat and sugar consumption in urban areas compared with the related rural communities, which usually have to depend on their staple crops of cereals, tubers, vegetables, and fruits.

Thus, there are social and economic pressures for developing countries to change their diet towards that of affluent societies. As urban societies grow and generate money, they also perceive the new diet, similar to that of other affluent communities, as a symbol of their newly acquired status. They therefore tend to adopt diets containing more animal products, fats, and sugars. Within the urban setting, the food industry can also flourish and exert substantial influence by promoting the consumption of soft drinks, meat products, confectionery, snack foods, and other convenience foods rich in free sugars and fats. This commercial activity is rarely based on health considerations; the consequences for the health of consumers may often be detrimental.

As the urban elite (e.g., government civil servants and other professional groups) in the developing world experience higher rates of cardiovascular disease and cancers, there is an inevitable increase in the demand for medical therapy of the kind found in affluent societies. The provision of high-technology, hospital-based medical care within the cities of developing countries both distorts the pattern, and escalates the costs, of health care.

Hypertension and heart disease are already major health problems in many African cities and are of rapidly increasing concern in Asia. For example, the prevalence of high blood pressure in both men and women is at least four times as high in urban as in rural areas of Ghana (*18*). The transition from village to urban lifestyles in Papua New Guinea, reviewed by Sinnett et al. (*19*), has been followed by increases in hospital admission rates for hypertension from 0.5 per 100 000 in 1961 to 7.5 per 100 000 in 1984. Hypertension was found especially in urbanized communities with

long periods of European contact, together with obesity and maturity-onset diabetes. More recently, a significantly increased number of cases of coronary heart disease has been reported in Papua New Guinea.

Urban populations in Latin America have patterns of mortality, in persons surviving childhood, very similar to those of Europe and North America. A study of 12 cities (2 "western" and 10 Latin American) showed that in all the cities, whether "developed" or "developing", the leading causes of death after childhood were cardiovascular diseases and cancer.

Major differences are now emerging between the health patterns of urban and rural areas in the developing world. Statistics used for the disease patterns of the developing world markedly underestimate the current impact of cardiovascular disease and cancers in urban communities in Africa, Asia, the eastern Mediterranean region, and Latin America. Large increases in the urban population are expected, especially in developing countries (*20*), and, with these, a deterioration in many aspects of the nutritional quality of food is likely. This suggests that there is an urgent need to rethink national agricultural and food policies for urban as well as rural communities, before governments in developing countries are perhaps overwhelmed by the demands for diagnosis and management of diseases that can now be linked to current and projected dietary changes.

2.2.2 *Trends in diet and chronic diseases in developed countries*

In developed countries, diseases related to life-style (including diet, alcohol consumption, smoking, and the level of physical activity) account for most morbidity and mortality. Age-standardized mortality rates for cardiovascular disease and cancers vary considerably among, as well as within, countries, as do rates for non-insulin-dependent diabetes, liver cirrhosis, dental caries, and bone diseases. These differences can be related to differences in behaviour patterns and particularly to diet. In Belgium, for instance, regional differences in mortality from ischaemic heart disease and in liver cirrhosis show a clear correlation with regional differences in the fatty acid composition and the alcohol content of the diet, respectively.

Age-adjusted mortality rates from cardiovascular diseases and from certain cancers have changed significantly in developed

countries but to very different degrees. For instance, changes in mortality from ischaemic heart disease in men aged 30–69 years between 1970 and 1985 ranged from −49% in the USA to +72% in Poland. Heterogeneous trends in mortality rates for cardiovascular disease in developed countries are largely unexplained in the absence of precise surveillance data on possible determinants. However, in some countries attempts have been made to explain the national changes. In the USA, the reduction in average blood cholesterol level was estimated to account for 30% of the decline in mortality rates for ischaemic heart disease (*21*). Taken as a whole, the evidence from comparisons among and within developed countries supports the view that a range of chronic diseases can be prevented to a substantial extent by life-style changes, among which diet plays a crucial role.

2.3 Changes in human dietary patterns: a longer-term view

2.3.1 *An evolutionary and historical perspective*

With changes in human culture and technology come changes in patterns of food production, processing, and storage. In addition, with increases in economic prosperity within populations (or segments of populations) come new consumer expectations and demands. Recent and continuing changes in diet in some developing countries resemble, to a variable extent, changes that have previously occurred in the diets of developed countries. A long-term historical view may help to set these changes in perspective.

2.3.2 *Major historical changes leading to the "affluent" diet*

The human diet has changed profoundly over what, in terms of the long and gradual process of human biological evolution, is a very short period of time. In most pre-agricultural societies, the supply of food was variable and uncertain, dependent on seasons, and often associated with periods of severe shortage or starvation. Deficiency diseases have been age-old companions of primitive and pre-industrialized societies. The human species is an unspecialized (omnivorous) eater, capable of surviving on a diet consisting mainly of meat, or one consisting almost entirely of vegetable matter (*22*). Anthropological studies of the diets of hunter-gatherer societies that have survived into the 20th century include that of the Bushmen of

the Kalahari Desert in southern Africa, and provide a valuable evolutionary perspective on modern dietary practices in developed countries. The typical diet of most of today's surviving hunter-gatherers, living in relatively fertile areas of the world, consists mainly of a wide range of different foods of plant origin plus some meat, which makes up about one-quarter of the diet by weight. The anthropological studies indicate that the fat intake of prehistoric people living in temperate climates was about 20% of total calories (i.e., half the current intake in developed countries) with an appreciably higher ratio of unsaturated to saturated fatty acids. Fibre intake appears to have been about 45 grams per day, compared with 15 grams or less in present developed-country diets, and the intake of vitamin C was several times as high as that now observed in affluent societies. Assuming that the modern human species, *Homo sapiens*, evolved 30 000 to 50 000 years ago, then the species has subsisted for most of its history on low-fat, high-fibre diets, rich in vitamin C and many other micronutrients, to which it presumably adapted biologically to achieve optimum function. The profile of foods consumed by the hunter-gatherer persisted until the first agricultural revolution approximately 10 000 years ago.

2.3.3 *Agricultural revolutions*

A greatly improved food supply followed the cultivation of crops in the first agricultural revolution. Continuity of food supplies became more certain, although still subject to drought, pests and other natural hazards. This led to a better nutritional status, better resistance to infection, and lower mortality in infancy and childhood. As population numbers increased, so did the pressure on the food supply, and this sometimes led to undernutrition and a new rise in mortality from infection.

The second agricultural revolution, dating from the mid-18th century in Europe, led to an unprecedented abundance of food—assisted by the introduction of the energy-rich potato from America, of legumes, and, in southern Europe, of maize. Crop rotation, mixed farming, and finally mechanized farm implements were also very significant developments. These improvements were sufficient to feed populations that trebled in size between the end of the 17th century and the mid-19th century.

As with the first agricultural revolution, these developments were associated with population increases, reflecting particularly a fall in

childhood mortality from infections, because of the improved nutritional status. The surplus population migrated to the cities and provided the work-force for the industrial revolution, but at the same time created a new pressure on food supplies. This provided a new impetus for technological developments in food processing, transport, and preservation.

Subsequently, in the second half of the 19th century, the "sanitary revolution" in Europe led to effective control of the waterborne diseases and some of the foodborne infectious diseases (e.g., typhoid fever). Nearly half of the fall in mortality from infectious diseases during those decades was attributable to reduced mortality from tuberculosis, due mainly to improvements in diet and housing; most of the rest was due to reduced mortality from typhus, other filth-related fevers, diarrhoea, dysentery, cholera, smallpox, and scarlet fever, in which an improved diet also played a significant role (*23*).

Concomitant with the increased production and the improved distribution of food were enormous technological changes in food processing. Also, edible plants and farm animals were improved by selective breeding. About 200 years ago, the Industrial Revolution also began to transform the life-styles of people in Western Europe and North America.

These agricultural and technological activities contributed to the development, in industrialized societies, of a modern diet that, in nutrient profile and energy content, is far removed from the diets of the hunter-gatherer and peasant-agriculture phases of human cultural evolution. In northern Europe and North America, these cumulative changes in diet have led to an increased supply of protein-rich foods, and also of saturated fatty acids, since animal storage fats are consumed in greater quantities, while the essential structural fatty acids found particularly in plants form a smaller part of the diet.

Fat intake rose steadily, fibre intake declined, and the consumption of free sugars rose as consumption of complex carbohydrates fell. The energy density of food has therefore increased in recent centuries, at a time when human energy expenditure (physical activity) has declined. Comparison between the diet of the late-Paleolithic time (Stone Age) and the current American diet shows large changes in protein, fat, sodium, potassium, and calcium intake (*24*).

Today, therefore, the human diet of developed countries is very different from that of about 150 generations ago, when the human

species lived on wild plants and animals. Even 10 generations ago, before the Industrial Revolution, diets were different. The most significant changes in the human diet have, in fact, taken place only during the last few centuries, and the human species has had virtually no time to adapt biologically to the rapid changes in the types and amounts of food available.

Table 9 gives figures for the United Kingdom that highlight some of the major dietary changes that have occurred over the last 200 years. The striking change is the substantial decline in the intake of complex carbohydrates accompanied by the progressive rise in fat and sugar consumption. These changes over a 200-year period are mimicked in many ways by the differences found today between the dietary patterns of hunter-gatherers and peasant agriculturalists in developing countries and of people in developed countries, which are illustrated in Fig. 6.

Recent approaches to nutrition in Europe and North America

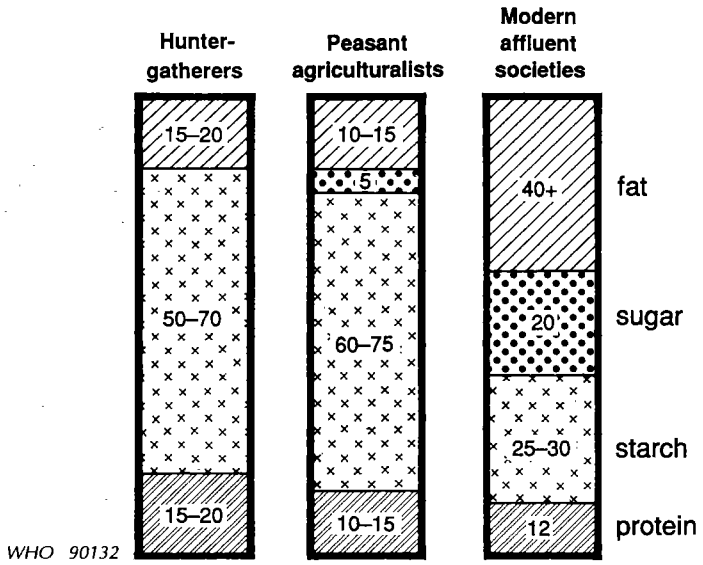
In the 1930s, the primary concern in Europe and North America was the elimination of deficiency diseases, and the widely promoted concept of a "balanced diet" arose from efforts to prevent these. This concept was based on the recognition that an appropriate mixture of food items would provide the minimum requirement of protein, vitamins, and minerals needed by the body. By the late 1950s, epidemiological research had begun to indicate that some chronic diseases that were not normally associated with undernutrition might nevertheless also be nutrition-related. Nutritional excess (or "overnutrition"), in parallel with nutritional deficiencies (e.g., of iodine and iron), thus became a focus of research. Since then, cumulative scientific evidence has confirmed and elaborated the role of diet in the development of many of these chronic diseases.

Table 9. Estimated per caput consumption in the United Kingdom of various foodstuffs, 1770, 1870, 1970[a]

Foodstuff	Grams per person per day		
	1770	1870	1970
Fat	25	75	145
Sugar	10	80	150
Potatoes	120	400	240
Wheat flour	500	375	200
Cereal crude fibre	5	1	0.2

[a]Reproduced from reference *16*, by kind permission of the publisher.

Fig. 6. Percentage of energy obtained from different food components and salt and fibre intakes of different human groups[a]



	Hunter-gatherers	Peasant agriculturalists	Modern affluent societies
salt (g/day)	1	5–15	10
fibre (g/day)	40	60–120	20

[a]Reproduced from reference *25*, by kind permission of the publisher, with slight modifications.

Thus, the concepts of the requirements for a balanced diet in developed countries have, in recent decades, changed radically from the needs recognized earlier this century, and are very different from those in preceding centuries. These new concepts are now becoming as relevant to developing countries as to developed countries.

2.3.4 *Dietary change in Latin America*

The native populations of Latin America have traditionally been agriculturalists with a wide variety of diets. Thus, before countries were governed by the Spanish and Portuguese there were diverse indigenous patterns of agriculture with, for example, potatoes, beans, and guinea-pigs forming the main dietary items in the highland regions of South America. Camelids, for example the llama and alpaca, were also a substantial source of meat and milk in

Bolivia, Chile, and Peru, as well as serving as beasts of burden and providing wool for clothing. In Mexico and in the northern parts of Central America, maize and red beans were the staple crops, with cassava, fruit, and a wide variety of other foods being grown in the jungle areas further south. These crops had been grown for centuries in South America and constituted major items of the diet. Thus, the common bean (*Phaseolus vulgaris* L.) was cultivated as long ago as 5000 BC, and probably even earlier in the mountainous regions of Peru. Maize was also the principal food of the ancient civilizations, including the Incas of Peru, the Mayas of Central America, and the Aztecs of Mexico. In the New World before the time of Columbus, maize was also the staple crop for a whole range of people who lived in southern Chile at altitudes below about 3300 metres.

After the Spanish and Portuguese conquests, rice was introduced into the lowland regions of Central America and cattle-rearing became a major agricultural activity in South America. On the other hand, the colonization of Central and South America led to the transfer of a large variety of foods across the world, e.g., maize, potatoes, tomatoes, and beans. Following the Spanish and Portuguese conquests, the dietary patterns continued to be diverse throughout the continent, but the populations still derived large proportions of their energy, proteins, and micronutrients from staples such as cereals (mainly maize in Mexico, Central America, and the tropical and subtropical regions of South America, rice in some parts of Central and South America, and wheat in northern Mexico and the southern segment of South America), legumes (black, red, or white beans in most of the continent) and tubers (potatoes in Andean regions and yams in northeastern Brazil). Other vegetables and a wide variety of fruits were available, but they were not eaten regularly in large amounts by most populations. Cane sugar was introduced as a cash crop and sugar has become a major source of dietary energy in several Latin American countries. Poultry, eggs and, to a smaller extent, pork, are now the most common foods of animal origin, although intake is relatively low. Cattle, although raised for export of meat in many countries, provide meat as a major food only in Argentina, southern Brazil, Uruguay, and the more affluent groups in other countries. Fish is not a common food, even in coastal areas and around the rivers and lakes.

Many diets are based on the habitual consumption of a few foods that supply most of the nutrients and dietary energy (for example,

the maize-and-beans food system of southern Mexico and Guatemala, or the yam-and-beans system of northeastern Brazil). These monotonous diets favour the development of specific nutrient deficiencies, e.g., of iron and vitamin A, and make it difficult, though not impossible, to satisfy the populations' energy and protein needs, especially in the case of young children.

South America is now seeing very substantial changes in diet, as urban communities grow and the patterns of demand influence the transport and sale of food; in most countries, 50–70% of the population still live in rural areas, and consume mainly cereals, legumes (beans) and other vegetables, with few animal foods. In Argentina, southern Brazil, and Uruguay, a special situation exists, the diet of large segments of the population being based on beef. Whereas subsistence farmers in the country continue to grow much of what they eat, city-dwellers rely on diets based on cereals or fibres and legumes, but these diets are rapidly changing to resemble more closely the North American and Western European diets. Processed and semi-processed foods have supplanted many staples, especially in urban and suburban areas. Aggressive commercial publicity and the impact of films, television, and magazines, which depict certain foods and beverages as being linked to higher social status, have increased the use of products with little or no nutritional value. These foods, rich in fat and sugar, have become important socially if not as yet in nutritional terms, and are now beginning to be substituted for the better traditional foods.

In the wake of urbanization, urban slums have emerged, resulting in drastic changes in food habits. The diet of slum-dwellers is of poor quality: legume consumption has decreased and malnutrition increased; some processed foods have been incorporated. The urban middle-income groups depend on local and processed foods containing more fats and free sugars, as well as more animal foods than rural diets. The higher-income groups have dietary patterns similar to North American or Western European diets, with relatively high consumption of animal foods, vegetable fats, and sugars. Smoking and the consumption of carbonated sugar-containing beverages and of alcohol are common in most countries. In general, physical activity has decreased as a result of urbanization among men, women, children of school age, and adolescents.

The food industry has also developed, and now has better means of communication and systems for the commercial distribution of foods. Better sources of proteins and micronutrients, as well as more

hygienic foods, have been introduced as a result, but an undesirable increase in the intake of fats, refined carbohydrates, and salt is also occurring.

With these rapid changes in the urban diet have come further problems of malnutrition in the last decade as a result of the economic crises that have affected most Latin American countries. These have forced the lower-income groups to replace some of the more expensive staples (e.g., animal foods and legumes) by cheaper, and often less nutritious, products.

The introduction of the African palm to South America as a source of oil has proved to be economically attractive. Production of the palm oil is increasing in many Latin American countries, and in some, such as Costa Rica and Venezuela, it is already a major source of dietary fat for the population.

2.3.5 *Dietary change in Africa*

The dietary patterns found in Africa have, for centuries, differed from country to country and region to region, with large differences in agricultural practices in the north, south, east, and west. The main dietary changes in Africa followed the slave trade and colonization —at the end of the 19th and the beginning of the 20th century. The development of an export trade in cash crops, such as cocoa, rubber, cotton, coffee, and sisal, meant that most of the good land was given over to cash crops. Food crops were grown only on the marginal and poor soils. High prices for cash crops and minerals—including petroleum—made it easier to import wheat, rice, and even beef from outside the continent. Analyses of the effects of cash-cropping on the dietary patterns and nutritional state of the people provide a very mixed picture. In some cases, cash-cropping has been disastrous, with a marked increase in the area of arid land (for example, in the sub-Saharan belt); but elsewhere, cash-cropping has been an effective way of increasing the food security of a region.

One of the major features of the social development of Africa is the very rapid increase in the population. High birth rates have meant that the population structure is dominated by a very high proportion of children. The increase in mouths to feed is now putting a great strain on food resources.

The production of local cereals and plant products like sorghum, millet, maize, yam, and plantain cannot keep up with the rising population, and cassava (which will grow on poor soil) has become

more and more important. In the rural areas, local food production on the marginal land cannot support the population explosion. Energy and protein insufficiency are common, while nutrient deficiencies are still seen. Since 1970, drought and other natural catastrophes have resulted in undernutrition or famine in more than 20 countries. This situation highlights the precarious food-supply situation in Africa.

The development programmes of most African countries include the promotion of greater reliance on locally produced foods and on greatly reduced importation of exotic, highly refined foods. Economic stresses, particularly in the present decade, have brought widespread dietary hardship and restrictions, especially among the lower-income populations in and around urban areas.

The process of urbanization in Africa can be exemplified by what has happened in the United Republic of Tanzania and Zimbabwe over the last 20 years. Traditionally, the population is agriculture-based, living in rural areas and consuming a home-produced cereal-based diet. Even today, 80% of the population live in the rural areas. Maize, rice, millet, and wheat, along with local meat, bananas, beans, green vegetables, and yams, could provide an adequately mixed traditional diet. Economic development over the past two decades has resulted in an overall increase in purchasing power and has brought about dietary behavioural changes in all segments of the population. This has resulted in three distinct population subgroups: rural, urban, and urban slum-dwellers.

The rural population has maintained the traditional diet, but total food intake, including fat, has increased. With increases in commerce, mining, and other industries, the population migration from rural to urban areas has generated the urban slums, whose residents are facing very serious dietary and nutritional inadequacy. Lack of physical exercise is resulting in obesity among non-working females of this subgroup. The urban elite, in contrast, though a small fraction, have drastically altered their food habits, influenced both by local and international food industries, and now tend to consume high-fat, energy-rich, high-salt, and processed sugar-based items. Soft drinks, alcohol, and ready-to-eat food items are popular, thus disturbing the traditional home-based diets. No special nutritional programmes are in operation in urban areas. Stroke, coronary heart disease, diabetes, and other diseases of affluence are increasing in this group. Thus the dual problems of undernutrition and overnutrition have emerged in the urban context, the latter tending

to increase the occurrence of chronic diseases among the urban elite population.

Some of the countries in the African region have now developed their own food and nutrition policies. Most of these aim to eradicate malnutrition, but it is important to maintain awareness of the emergence of overnutrition and its resultant effect on chronic diseases. This awareness should not be limited to the urban elite, but should encompass the emerging affluent commercial/business sector in rural areas and small towns.

2.3.6 *Dietary change in China*

In all countries, dietary patterns change with socioeconomic development. In ancient China, as a result of the great disparity in socioeconomic situation between the feudal nobles and the common people, a basic dietary pattern of high-cereal, high-vegetable intake had developed for the common people, while, at the same time, a different cereal-based dietary pattern, high in meat and fish, existed for the rich. About 2000 years ago, Confucius taught his students: "The higher the quality of foods the better, and never rely upon the delicacy of cooking". Consequently, the concept of enjoying a diet high in animal food, and a preference for meat and greasy foods, have been shaped over hundreds of years. So, in the earliest medical classics, a dietary guideline based on experience was given as: "Cereals—the basic, fruits—the subsidiary, meat—the beneficial, vegetables—the supplementary", which gives a hint of the prevalent dietary problems from the medical point of view.

Since the founding of the People's Republic of China, social change and intensive preventive activities have made tremendous progress in controlling infectious and parasitic diseases. Consequently, annual population mortality rates have decreased to 6–7 per thousand and life expectancy has increased to 68 years. Food security policies have been established that assure the basic needs in staple foods and edible oil for the whole urban and rural population.

Economic reform and the new policy for agriculture over the past 10 years have accelerated agricultural and industrial development, resulting in widespread food adequacy and increased per caput income. There has been a rapid increase in the consumption of foods of animal origin from 26.5 kg/year per caput in 1957 to 47.7 kg/year in 1984. Oil intake has also increased as a result of excellent harvests of oil-seed crops. Thus, the national dietary pattern is moving

towards larger quantities of animal food, higher fat intake, and smaller quantities of cereals.

The process of urbanization in China has been slower than in other developing countries because of official policy; 75% of the population are now in rural areas. Owing to the increase in agricultural production and the doubled or tripled average income, the diet in rural areas has been changing towards higher meat and fat intakes—but it is still basically a cereal-based diet. In large cities such as Beijing and Tianjin, the trend to high consumption of meat and fat has been marked, with 30% of energy being derived from fat.

2.3.7 *Dietary change in India*

Over time, traditional regional diets have emerged in India, and these have been based primarily on local agricultural practices, climate, and religious beliefs. Despite many centuries of cultural invasions, traditional diets remained unchanged, although some newer dietary habits were added. Diets were usually carefully prescribed in many parts of India to suit occupation, health and physiological status, and the amount of physical activity. Times for eating were prescribed, overeating was prohibited, and vegetarian diets were recommended. Until recently, locally grown agricultural products have dominated diets in India, thus creating distinct rice-based, wheat-based, and millet-based diets.

Because of religious traditions and taboos, the inclusion of meat, especially pork, in the diet remains very limited. In recent decades, developments in food storage and distribution systems have resulted in the ability to move food grain to different parts of the country, and cultural interactions have further modified the typical regional diets. Nevertheless, the majority of the population continue to eat a cereal-based diet.

Gopalan (*26*) stated that the important dietary changes that take place as Indian populations move up the socioeconomic scale appear to be:

1. An increased intake of legumes, vegetables, milk and, in case of non-vegetarians, foods of animal origin—changes that may be considered beneficial from the nutritional point of view.
2. Substitution of millet (coarse grain) by the more prestigious cereals, wheat and rice, with a progressively increasing preference for the highly polished varieties of rice with increasing socioeconomic advancement. This change is usually accompanied

by a reduction in the overall cereal intake (though cereal intake continues to be relatively high by European and North American standards, even in the most affluent Indian groups).These changes have resulted in a decrease in the overall fibre content of the diet. The total substitution of millet by polished rice or refined wheat results in a reduction in the fibre content of the diet of more than 50%.

3. Progressive increases in the intake of edible fat, with increasing preference for hydrogenated fats in the place of vegetable oils (in the case of the middle classes) and, in the most prosperous segments, a relatively high intake of ghee (clarified butter). The diet of nearly 17% of the rural poor does not include any edible oil, whereas fat intake in the diet of the top-income bracket in the country could provide over 30% of the energy in the diet. The distribution of fat intakes in Indian populations is highly skewed, with about 5% of the population consuming nearly 40% of the available fat.
4. Increased intake of sugar and sweets (which the poor can hardly afford).
5. Increase in the overall energy intake in relation to energy expenditure—leading to obesity.

The "invisible" fat intake in the diets of even poor Indians ranges from 20 to 50 g daily. The linoleic acid derived from "invisible" fat contributes an average of 4.8–7.0% of the dietary energy. Even poor Indian diets are reasonably adequate in fat.

During the last three decades, increases in urbanization, and the availability of cafeteria or hotel-based meals in the cities and towns explain these dramatic changes in the long-standing cultural dietary habits. Tea, coffee, soft drinks, and snacks are now also consumed widely among both the middle-income and the poorer segments of the population. Smoking and alcohol consumption have increased in many population groups. Physical exercise has decreased among the urban populations, contributing to obesity.

2.3.8 *Dietary change in Japan*

Japan was relatively isolated from Western influences until the latter half of the 19th century. It was a feudal society in which the average person's diet was low in food and nutrients (Table 10). Changes in the diet were relatively small until after the Second World War.

Table 10. Changes in daily per caput intakes of nutrients and major groups of foods in Japan, 1850–1987

Nutrient/Food	1850[a]	1952[b]	1980[b]	1987[b]
Energy ($kcal_{th}$)	<1800	2109	2119	2075
Protein (g)	<50	70.0	78.7	78.9
Animal protein (g)	<20	22.6	39.2	40.1
Total fat (g)	<10	20.1	55.6	56.6
Animal fat (g)	<5	7.0	26.9	27.9
Carbohydrate (g)	<380	412	309	295
Rice (g)	<350	352	225	212
Meat (g)	<5	10.6	17.9	70.8
Milk (g)	0	10.6	115.2	117.9
Fish (g)	<60	82.3	92.5	90.5

[a] From an old book referring to the Edo area.
[b] Ministry of Health and Welfare of Japan, National Nutrition Survey.

The Japanese Ministry of Health and Welfare has conducted National Nutrition Surveys every year since 1946. There have been large increases in meat and fat consumption. The average energy intake derived from fat has increased each year and reached 24% in 1980. Intakes of rice fell substantially during the 1960s and 1970s with a marked increase in fruit consumption as well as in milk intake. In 1988, 15.3% of energy consumed came from protein and 59.9% from carbohydrate. Intakes of dietary fat, saturated fat, cholesterol, sugar, dietary fibre, and protein are all at present estimated to be within acceptable limits. Salt intake is an exception, but has been falling progressively and had reached a value of 12.3 g per person per day in 1982. Although in recent years the average intake of calcium has been slightly less than recommended, intakes of the other nutrients have been estimated to exceed the recommended daily allowance.

The well recognized secular increase in the growth rates of Japanese children seems to be closely linked to the intake of dietary protein, particularly from animal sources. The population over 65 years of age is now rapidly increasing and it is predicted that more than one in five persons will be over 65 years of age by 2020. These changes in life expectancy reflect improvements in diet and a reduction in premature mortality from pneumonia, bronchitis, and tuberculosis since the end of the Second World War, with a later decline in mortality from cerebrovascular disease. There has been a progressive increase in mortality from cancer, diabetes, and heart disease. These adverse developments led the Japanese Dietetic Association in 1984 to call for the development of dietary guidelines

and nutrition policies in Japan (*27*). They noted the adverse trends in fat consumption and the very large variations in the eating habits of different families. They proposed the avoidance of excess intakes of salt, fat, and energy and promoted an increase in the consumption of unrefined cereals, vegetables, legumes, mushrooms, and seaweeds. They proposed a fat intake, for individuals, of 20–25% of energy with a very low content of saturated fatty acids; the polyunsaturated fatty acids, derived particularly from fish, should be half of the total fat intake.

Thus, the Association recognized the need to reverse some of the current trends in the food habits of the Japanese. Priority policies supporting activities for the improvement of nutritional status in Japan are as follows:

1. Nutrition survey system—conducted annually by the Ministry of Health and Welfare.
2. Nutrition education system, including school lunches.
3. Health care system—there are more than 10 000 hospitals (more than 20 beds) and 850 health centres in Japan.
4. Cooperation of the food industries. For example, tasty low-fat "hamburgers" are made from soya-bean protein and distributed for school lunches.

3. A SUMMARY OF THE RELATIONSHIPS BETWEEN DIET AND CHRONIC DISEASES

Given the extensive medical research over the last four decades into the link between diet and chronic disease, only a brief overview of the evidence is possible and readers are advised to consult the references cited, and previous WHO reports dealing with individual diseases, for a more detailed exposition.

3.1 Nature of research and evidence used

The evidence relating diet to chronic diseases comes from epidemiological investigations and from controlled trials in human beings. Laboratory experiments on animals and *in vitro* tests on tissues have also contributed to an understanding of the relationships between diet and the various chronic diseases described in this section. The links have been established on the basis of data

from all these sources, and the analysis takes into account the strengths and weaknesses of the different types of study.

Descriptive epidemiological investigations of the relation between dietary factors and chronic diseases have yielded important hypotheses and valuable data, but they cannot be used alone to establish causality or to estimate the strength of the association between diet and diseases. Analytical epidemiological studies, such as cohort studies and case-control studies that compare information from sets of individuals within a population, usually provide more accurate estimates of such associations. The most consistent correlations between diet and chronic diseases have been obtained from comparisons of populations or population subgroups with substantially different dietary habits. In contrast, it is often more difficult to identify a diet–disease association within a population where the diets of the individual members are fairly homogeneous.

While the epidemiological evidence depends on observations made in whole populations or population subgroups, every population consists of individuals who may vary in their susceptibility to each disease. Part of this difference in susceptibility occurs for genetic reasons. As the dietary or social conditions within a population change in the direction that increases the risk of a specific disease, so an increasing proportion of individuals, particularly those who are most susceptible, develop the disease. For researchers, an important consequence of this inter-individual variability in susceptibility to disease is that some diet–disease relationships are difficult to identify within a single population, even though diet may strongly influence the average risk of disease occurrence within that population as a whole. In that case, the diet–disease relationship may be most evident in comparisons between populations that have different average (per caput) dietary intakes.

In controlled trials and experimental clinical studies, long exposure is usually required for the effect of a diet on the risk of chronic disease to become evident. Furthermore, it may be necessary to have strict selection criteria for participants in such studies in order to show an effect with small numbers in a reasonable time. This selection process may result in restricted and homogeneous study samples, which then may limit the applicability of results to the general population. Despite the limitations of the various types of study in human beings, repeated and consistent findings of an association between specific dietary factors and a disease suggest

that such associations are real and indicative of a cause-and-effect relationship.

Experimental studies on animals make it possible to investigate more closely the links between diet and disease. However, extrapolation of data from animal studies to human beings is restricted by the limitations of animal models in simulating human diseases and human diets, and by differences in absorption and in metabolic processes among species. Thus, more confidence might be placed in data derived from studies on more than one animal species or test system, on results that have been reproduced in different laboratories, and on data that indicate a dose–response relationship.

Therefore, in addition to considering the strengths and weaknesses of each kind of study discussed above, and placing most confidence in data from studies on human beings, the significance and consistency of the data and the agreement between epidemiological, clinical, and laboratory evidence need to be taken into account in reaching conclusions about the influence of diet on the occurrence of chronic diseases.

3.2 Cardiovascular diseases

The most frequent cardiovascular diseases are obliterative atherosclerosis, arterial thrombosis, and hypertension. Each may be influenced by diet. Most evidence from studies in human beings relates to the effect of dietary variables on lipid and lipoprotein fractions, especially total and low-density lipoprotein cholesterol. The following section deals mainly with the relations between different dietary variables and serum total cholesterol, and with the relation between serum total cholesterol and the risk of coronary heart disease. The relation between high blood pressure and cerebrovascular disease will also be discussed.

3.2.1 *Coronary heart disease*

Coronary heart disease (CHD) as a public health problem became evident in Europe and North America early in this century. By the 1950s it had become the single major cause of adult death, and suspicions then began to emerge as to its likely causes. The approximately fivefold difference in rates among various developed countries (e.g., Finland compared with Japan) and the intra-

population variation in rates, by socioeconomic class, ethnicity, and geographical location, emphasized the environmental basis of the condition. Further evidence for environmental determinants comes from the marked shifts in CHD rates seen in migrant populations that move across a geographical gradient in CHD risk and change their life-style.

On the cross-cultural level, the relation between diet and CHD was supported by the results of the Seven Countries Study (*28, 29*). In the seven countries, saturated fat intake varied between 3% of total energy in Japan and 22% in eastern Finland. Average serum total cholesterol values in these populations amounted to 4.3 mmol/l (165 mg/dl) in Japan and 7.0 mmol/l (270 mg/dl) in eastern Finland. The 15-year CHD incidence rates varied between 144 per 10 000 in Japan and 1202 per 10 000 in eastern Finland. The results suggested that, on a population level, serum total cholesterol was strongly related to the incidence of CHD. A strong correlation was also observed between the intake of saturated fat and serum total cholesterol, suggesting that the variation in serum total cholesterol level between populations could be largely explained by differences in saturated fat intake.

On a population basis, the risk of CHD rises progressively with increases in serum total cholesterol from 3.89 mmol/l (150 mg/dl). For many countries the whole population may be described as being at high risk. Studies in rural parts of China indicate an average total cholesterol level of 3.24 mmol/l (125 mg/dl) and this population has an incidence of CHD of only 4% of that observed in Great Britain. The concept of a "normal" total cholesterol, therefore, has little meaning; observational studies suggest that one population with an average total cholesterol level 10% lower than that of another will have one-third less CHD, and a 30% difference in total cholesterol predicts a fourfold difference in CHD.

The Seven Countries Study showed a strong positive relation between saturated fat intake and the 10-year incidence of CHD (*30*). There was some suggestion of a curvilinear relationship in these data, which became clearer when the follow-up period was extended to 20 years. Populations with an average saturated fat intake between 3% and 10% of energy intake were characterized by a serum total cholesterol level below 5.17 mmol/l (200 mg/dl) and by low mortality rates from CHD. When saturated fat intake was greater than 10% of energy intake a marked and progressive increase in CHD mortality was observed.

The role of different unsaturated fatty acids, e.g., mono-unsaturated and *n*–3 and *n*–6 polyunsaturated fatty acids, in the prevention of CHD remains unclear. Populations in some Mediterranean countries with a high intake of total fat (more than 40% of energy) derived predominantly from mono-unsaturated fatty acids (olive oil) have low rates of CHD. Eskimos, who also have a diet high in total fat and in *n*–3 polyunsaturated fatty acids, mainly derived from marine foods, also have low CHD rates. The diets of these populations are also, however, characterized by a low intake of saturated fatty acids. This may explain their low CHD rates. Populations with a long-standing intake of *n*–6 polyunsaturated fatty acids above 7% of energy do not exist. Therefore, information on the public health consequences of diets with amounts of *n*–6 polyunsaturated fatty acids above this level is not available.

Epidemiological studies carried out on middle-aged men provide clear evidence that the risk of CHD in individuals is increased by three major factors: high serum total cholesterol, high blood pressure, and cigarette smoking (*31*). There is also synergism between the risk factors, i.e., the presence of several risk factors, simultaneously, increases the risk of the disease more than would be expected from the sum of the individual risk factors. The fundamental importance of diet in the development of coronary heart disease is mediated through its effects on the development of hypercholesterolaemia and hypertension. Body-weight changes induced by changes in diet and physical activity are strongly related to changes in serum total cholesterol and blood pressure, and obesity is strongly related to diabetes, which is a further risk factor for CHD.

Several prospective studies have shown an inverse relation between high-density lipoprotein cholesterol and CHD incidence. Several negative correlates of high-density lipoprotein cholesterol have also been identified, e.g., overweight, alcohol abstention, smoking, and physical inactivity. This form of cholesterol seems, however, not to play an important role in explaining differences in CHD mortality between populations, and its dietary determinants will therefore not be discussed.

There has been substantial experimental work relating change in dietary lipid components to serum total cholesterol response. Although the earlier studies related dietary change to serum total cholesterol, it is now accepted that total cholesterol is an indicator of the atherogenic low-density lipoprotein fraction. Early work suggested that saturated fatty acids elevate serum cholesterol while

polyunsaturated fatty acids reduce the level; mono-unsaturated fatty acids tended to have little direct effect but the relationship does not hold for all individual fatty acids, or necessarily for all isomers of the fatty acids (e.g., the *trans* fatty acids). However, saturated fatty acids with 12–16 carbon atoms have been found consistently to elevate serum levels of low-density lipoprotein cholesterol, and dietary cholesterol itself has predictable effects on serum cholesterol at very low intakes. Major individual variations in responsiveness were also evident.

Other dietary components, such as dietary fibre, have an effect on serum cholesterol in experimental studies and are correlated in intercountry comparisons. As with the fatty acids, the different forms of dietary fibre may have different effects on serum cholesterol. The dietary factors that affect serum cholesterol in a similar way tend to cluster together in many diets. Thus, as one compares national diets rich in foods of animal origin and refined cereals with a more "vegetarian" diet typical of many developing countries, the total fat, saturated fat, and cholesterol contents are greater, the content of polyunsaturated fatty acids, as a proportion of total fat, tends to be less, and the dietary fibre content also tends to be less. Since all these factors can affect serum cholesterol, their combined effects may be important in modifying the rate of progression of atherosclerosis. These concordant trends in diet also make it difficult to assess quantitatively the effects of the individual factors on the atherosclerosis process.

Population subgroups consuming diets rich in plant foods have lower CHD rates than the general population. For example, Seventh-Day Adventists in the Netherlands and Norway have CHD rates that are one-third to one-half of those in the general population. Californian Seventh-Day Adventists who eat meat have higher rates than do those who are vegetarians, and British vegetarians have a 30% lower rate of CHD mortality than non-vegetarians once an allowance is made for their lower rates of cigarette smoking. Serum cholesterol levels among vegetarians are significantly lower than among lacto-ovo-vegetarians and non-vegetarians.

Alcohol consumption also influences the occurrence of CHD. A slightly lower risk of CHD in light-to-moderate drinkers than in abstainers was shown in a number of observational studies in Israel, Scotland, the USA, and Yugoslavia. However, a recent study from the United Kingdom suggests that this association can be partly or

wholly explained by the inclusion in the group of abstainers of ex-drinkers who had stopped drinking for health reasons (*32*). Alcohol ingestion does cause a favourable rise in the anti-atherogenic high-density lipoprotein fraction, but many epidemiological studies show that moderate and heavy drinkers have higher blood pressures than non-drinkers, and that abstinence from alcohol is followed by a fall in blood pressure.

Controlled trials in human beings using diet or drugs to reduce serum cholesterol show a reduction in the incidence and progression of CHD. Two carefully organized trials for the primary prevention of CHD, based only on dietary changes, showed that changing from a high to a low intake of saturated fats and replacing the fat with *n*–6 polyunsaturated fatty acids (such as linoleic acid) reduced serum cholesterol by 15% and led to a reduction of CHD incidence (*33, 34*).

Experimental studies showed an independent effect of dietary cholesterol on serum total cholesterol. This effect is smaller than that of saturated fatty acids. In several prospective cohort studies, an independent effect of dietary cholesterol on CHD incidence can be observed, a change of 200 mg of dietary cholesterol per 1000 $kcal_{th}$ (or 4.184 MJ) being associated with a 30% change in CHD incidence (*35*). Dietary cholesterol therefore contributes to CHD risk, and a population average intake of less than 300 mg/day has been recommended by most international committees.

A low intake of saturated fatty acids is the preferred option for preventing coronary heart disease and is the strategy that is still accepted by numerous international committees. In most developed countries, a high total fat intake coincides with a high saturated fat intake—diets with 40% of energy from total fat often provide 15–20% of the energy from saturated fat. Reducing total fat intake to 30% of energy will therefore have a substantial effect on saturated fatty acid intake in those populations, but should still allow the different unsaturated fatty acids to contribute up to 20% of energy. An FAO/WHO expert group concerned with dietary fats and oils in human nutrition recommended that 3% of energy should be taken as the lower limit for the essential fatty acid content of the diet (*36*).

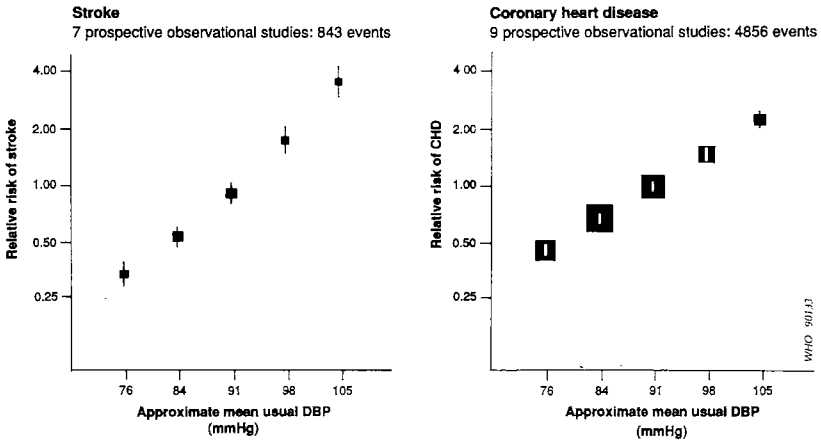
3.2.2 *High blood pressure and cerebrovascular disease*

The topic of high blood pressure and cerebrovascular disease has been dealt with more extensively in previous WHO publications (*30,*

37–40), but recent analyses reinforce the need for preventive measures to limit the development of hypertension. The risk of both CHD and stroke increases progressively throughout the observed range of blood pressure (see Fig. 7) with an impressive consistency of data in each of nine major studies conducted in a number of different countries. When all the data are combined in a statistically appropriate manner, it is clear that there is a fivefold difference in CHD and a tenfold difference in risk of stroke over a range of diastolic blood pressure of 40 mmHg (5.33 kPa). Observational studies, when combined, show that a sustained difference of only 7.5 mmHg (1.0 kPa) in the diastolic blood pressure confers up to a 28% difference in risk of CHD and a 44% difference in the risk of stroke. Since in many developed countries, the risk of CHD may be three to six times that of stroke, the population benefit of a lower blood pressure will have its greatest impact by reducing the number of cases of CHD.

The combined results of therapeutic trials of drug therapy used to lower blood pressure provide data on 37 000 patients and show (Fig. 8) a marked reduction in the incidence of stroke, but a lower-

Fig. 7. Association between usual diastolic blood pressure (DBP) and risk of stroke and coronary heart disease[a, b]



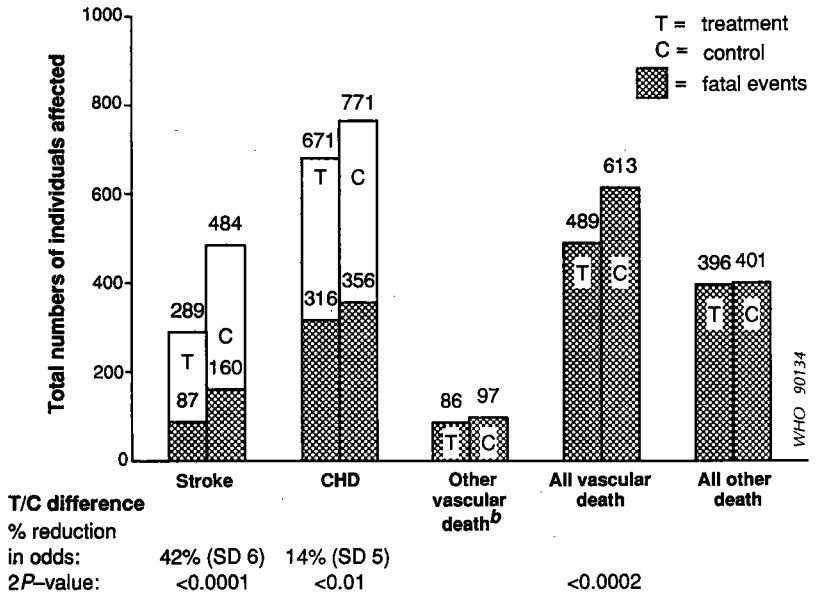
[a] The size of the boxes is proportional to the amount of information in each DBP category. The vertical lines denote 95% confidence limits. Values for mean usual DBP were estimated from later remeasurements in the Framingham study.

[b] Reproduced from reference *41*, by kind permission of the publisher.

than-expected effect in lowering the incidence of CHD. Diuretics were used in several of the trials and these drugs increase plasma cholesterol by 3–5%, which in turn would be expected to increase CHD rates by 5–10%. The benefits of lowering blood pressure are clear in both primary and secondary preventive trials, and there is no threshold below which a further lowering of blood pressure is without effect. One would therefore expect a primary preventive approach to be of major benefit since dietary manipulations, e.g., to reduce weight and restrict alcohol intake, have well recognized effects in lowering blood pressure. Some individuals also seem to benefit from a lower salt intake.

A recent large-scale multinational study (the Intersalt Study), involving 52 centres in 32 countries around the world, assessed the role of obesity, alcohol, and mineral intake in determining the progressive rise in blood pressure seen with age in most countries. A

Fig. 8. The overall effect of drug therapy in lowering high blood pressure in randomized trials on 37 000 subjects[a]



[a] Reproduced from reference *42*, by kind permission of the publisher.
[b] Excludes death from stroke or CHD but includes death from unknown causes.

high body-mass index[1] and high alcohol intake had strong, independent effects on blood pressure. Salt (sodium chloride) intake (assessed from a single 24-h urine collection) had a weaker but significant effect on the rise in blood pressure with age. In the four populations with a particularly low salt intake of below 3 g/day, no increase of blood pressure with age was observed, but a salt intake of 6 g/day may be a more reasonable estimate of a safe upper limit. Other minerals measured, e.g., potassium and magnesium, seemed to play a role in limiting the rise of blood pressure and are readily found in diets rich in complex carbohydrates, which also contain a variety of other minerals that were not studied (*11*). Some, but not all, cross-sectional and intervention studies suggest a beneficial effect of calcium intake on blood pressure, but at the moment there is not enough evidence to justify a recommendation for an increased calcium intake. Epidemiological studies consistently suggest lower blood pressures among vegetarians than non-vegetarians independent of age, weight, and pulse rate. Although it is not easy to determine the precise cause of these findings, these studies suggest that some component of animal products, possibly protein or fat, may influence blood pressure in well nourished populations.

As with obesity and hyperlipidaemia, there is evidence of inter-individual variations in susceptibility to hypertension, but the long-term interactions with dietary factors are less easy to discern. Nevertheless the recently collated data from research conducted over decades, shown in Fig. 7 and 8, emphasize the importance of the proposals in previous WHO reports for a primary preventive approach, with interventions geared to limiting the development of obesity and the intake of alcohol and salt. Increased dynamic physical activity may reduce blood pressure independently of its effect on weight change, and an increase in total dietary fat may also have an effect in promoting hypertension as well as obesity. Further research is needed but the evidence for marked environmental effects on blood pressure is clear. A recommendation to maintain normal weight with a diet low in fat and high in complex carbohydrates, and minimize the intake of alcohol is relevant to the avoidance of both obesity and hypertension; a low salt intake may also be beneficial in preventing the rise in blood pressure that is apparent in developed countries from early childhood.

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[1] Body-mass index = body mass in kg/(height in metres)^2.

3.3 Cancer

The relationships between specific dietary components and cancer are much less well established than those between diet and cardiovascular diseases. This is reflected in reviews of diet and cancer (43–45). However, the overall impact of diet on cancer rates throughout the world appears to be significant. For populations in developed countries, where cancer rates are highest and account for approximately one-quarter of all deaths, some epidemiologists estimate that 30–40% of cancers in men and up to 60% of cancers in women are attributable to diet (*46*).

The evidence for the influence of diet on cancer risk is derived from several sources. Correlations between national and regional food consumption data and cancer rates, and studies of the changing rates of cancer in populations as they migrate from a region or country of one dietary culture to another, have led to many important hypotheses. Case-control studies of the dietary habits of cancer patients and comparison subjects, and prospective studies of populations with known dietary habits, provide stronger evidence for the effects of diet in relation to major cancers. Many of these observations from human populations have been supported by animal experimental data.

Studies of diet in relation to some cancers have been confined to relatively homogeneous populations and have not been replicated across a range of cultural and dietary settings; for other cancers, the research has been pursued over a wider range of dietary intakes. Included among the cancers that have been linked repeatedly to dietary factors in different populations are cancers of the oral cavity, pharynx, larynx, oesophagus, stomach, large bowel, liver, pancreas, lung, breast, endometrium, and prostate.

3.3.1 *Cancers of the oral cavity, pharynx, larynx, and oesophagus*

In developed countries, epidemiological studies clearly indicate that drinking alcoholic beverages is causally related to cancers of the mouth, pharynx, oesophagus, and upper part of the larynx (*47*). There is no indication that the effect is related to the type of beverage. Smoking also causes cancers at these sites. There is also some evidence that cancers of the mouth and throat are increased by poor oral and dental hygiene.

In correlation studies conducted in different parts of the world, investigators have found positive associations between oesophageal

cancer and several dietary factors, including (*a*) low intakes of lentils, green vegetables, fresh fruits, animal protein, vitamins A and C, riboflavin, nicotinic acid, magnesium, calcium, zinc, and molybdenum; (*b*) high intakes of pickles, including salt-pickled vegetables, and mouldy foods containing *N*-nitroso compounds; and (*c*) consumption of foods and beverages at very high temperatures. The reported associations are consistent with the general hypothesis that certain nutrient deficiencies, such as are found in many high-risk populations, including heavy alcohol drinkers, might increase the susceptibility of the oesophageal epithelium to neoplastic transformation.

Case-control studies of oral and laryngeal cancers have also shown an increased risk associated with infrequent ingestion of fruit and vegetables.

3.3.2 *Stomach cancer*

A high incidence of stomach cancer is found in Japan and other parts of Asia and in South America, but not in North America or Western Europe where the rates are low and still decreasing. In the United States of America, stomach cancer rates are now among the lowest in the world, whereas in 1930, this was the leading cause of cancer death for men and the second leading cause in women. Gastric cancer incidence is decreasing in Japan, and a gradual decline in incidence over several generations has been noted among Japanese migrants to Hawaii. It seems most likely that these trends are related to changes in food consumption patterns, since several dietary factors have been implicated in gastric cancer risk. Stomach cancer is associated with diets comprising large amounts of smoked and salt-preserved foods (which may contain precursors of nitrosamines) and low levels of fresh fruits and vegetables (acting as possible inhibitors of nitrosamine formation). Dietary shifts away from this pattern could explain the declines in stomach cancer mortality in industrialized nations over the past 50 years, but the evidence is not conclusive.

3.3.3 *Colorectal cancer*

International comparisons indicate that diets low in fibre-containing foods and high in fat increase the risk of colon cancer. The initial suggestion that a lack of dietary fibre might increase the

occurrence of large bowel cancer came from observations of the virtual absence of this cancer in southern Africa. The indigenous populations were known to eat a lot of plant foods, and to have much higher faecal weights than populations from industrialized countries.

Several studies also demonstrate positive associations between the risk for colorectal (primarily colon) cancer and dietary fat. In general, the data suggest that saturated rather than unsaturated fatty acids may be responsible for this effect. In other studies, positive associations have been found between meat consumption and this cancer, but many studies have also shown no relationship between fat or meat intake and colorectal cancer. Several case-control and cohort studies provide suggestive but inconclusive evidence that drinking alcoholic beverages, in particular beer, has a causal role in the development of rectal cancer.

The data relating dietary fibre *per se* to colorectal cancer are equivocal. Although several studies have shown inverse relationships between the intake of high-fibre foods and colon cancer risk, these foods (vegetables to a large extent) are rich sources of other nutritive and non-nutritive constituents with potential cancer-inhibiting properties. Lower rates of colorectal cancer in Californian Seventh-Day Adventists, half of whom are vegetarians, support a protective effect of a vegetarian diet, although this group also abstains from alcohol.

In summary, an increased risk of colorectal cancer appears to be associated with high fat intake (particularly saturated fats) and low vegetable intake. It is not clear whether dietary fibre *per se* is protective or whether the apparent effect is due to other food constituents. Rectal cancer risk may be increased by the consumption of beer.

3.3.4 *Liver cancer*

Primary liver cancer is relatively rare in North America and most developed countries, but it is common in sub-Saharan Africa and south-east Asia, where it is associated primarily with exposure to hepatitis B virus infection. Liver cancer incidence and mortality, by geographical area, or among different population groups, have been correlated with aflatoxin contamination of foodstuffs in Africa. On the basis of evidence in developed countries, consumption of alcoholic beverages is causally related to liver cancer (*47*).

3.3.5 *Lung cancer*

In most industrialized countries, lung cancer is the leading cause of cancer deaths among men, and it is rapidly approaching this status among women. The most important causal factor is cigarette smoking. Lung cancer risk in males is clearly increased by certain occupational exposures (e.g., to asbestos, nickel, chromate, or gamma-radiation), several of which have been shown to interact synergistically with smoking.

Studies in several different populations have shown an interactive effect between smoking and a low frequency of intake of green and yellow vegetables rich in beta-carotene. These findings are consistent with experimental data showing tumour inhibition by vitamin A and synthetic analogues. In prospective studies, the frequency of consumption of beta-carotene-containing foods and the concentration of beta-carotene in serum have been inversely associated with the risk of lung cancer, but early reports of a similar inverse association for serum retinol (vitamin A) have not been confirmed in subsequent studies. Dietary fats and dietary cholesterol have also been positively associated with lung cancer risk.

3.3.6 *Female breast cancer*

Several lines of evidence support the importance of dietary factors in the causation of breast cancer. The first derives from animal experimental studies, which have demonstrated that, both with and without the presence of known mammary carcinogens, the incidence of mammary tumours in rats increases substantially with diets high in total and saturated fat, provided that the diet contains a small amount of polyunsaturated fat. A role for fat and other dietary factors is also supported by descriptive epidemiological studies, correlation studies, case-control and cohort studies, and evaluations of nutrition-mediated biological risk factors.

Correlation studies provide evidence of a direct association between breast cancer mortality and the intake of energy, fats, and specific sources of dietary fats, such as milk and beef (see, for example, Fig. 9, page 68). Several case-control studies have associated breast cancer risk with dietary constituents, especially fats. However, not all studies show these relationships.

There is epidemiological evidence—not fully consistent—relating alcohol consumption to the risk of breast cancer in women. It is, at present, unclear whether this association is causal.

3.3.7 *Endometrial cancer*

A strong association between endometrial cancer risk and excess weight has been reported in several studies, and a hormonal mechanism has been postulated for this association. Specific dietary factors other than obesity have not been identified for this disease.

3.3.8 *Prostate cancer*

International incidence and mortality data generally show a positive correlation of prostate cancer with the incidence of other diet-related cancers, including cancers of the breast, corpus uteri, and colon. Inter- and intra-country analyses show positive correlations between mortality from prostate cancer and per caput intake of total fat. These findings have been supported in analytical studies showing an association of prostate cancer with the intake of high-fat foods.

Although studies of certain other cancers suggest that vitamin A and, in particular, beta-carotene may be protective factors, some case-control studies indicate that beta-carotene may be a risk factor for prostate cancer, especially among men aged 70 years and older. Increased weight or obesity has also been positively associated with the risk of prostate cancer.

3.3.9 *Summary and conclusions: major associations between diet and cancer*

Table 11 summarizes the strength of association between dietary components and cancers at various sites. A review of the evidence indicates that a high intake of total fat—and in some case-studies also saturated fat—is associated with an increased risk of cancers of the colon, prostate, and breast. The evidence is strongest for cancer of the colon, and weakest for breast cancer. The epidemiological evidence is not totally consistent, but is generally supported by laboratory data from studies in animals. The experimental data, however, also point to an adverse effect of very high intakes of polyunsaturated fats, at levels that are considerably above current intakes in human populations.

Diets high in plant foods, especially green and yellow vegetables and citrus fruits, are associated with a lower occurrence of cancers of the lung, colon, oesophagus, and stomach. Although the mechanisms underlying these effects are not fully understood, such

Table 11. Associations between selected dietary components and cancer[a]

Site of cancer	Fat	Body weight	Fibre	Fruits and vegetables	Alcohol	Smoked, salted, and pickled foods
Lung				−		
Breast	+	+			+/−	
Colon	++		−	−		
Prostate	++					
Bladder				−		
Rectum	+			−	+	
Endometrium		++				
Oral cavity				−	+[b]	
Stomach				−		++
Cervix				−		
Oesophagus				−	++[b]	+

Key: + = Positive association; increased intake with increased cancer.
− = Negative association; increased intake with decreased cancer.
[a]Adapted and extended from reference *44*.
[b]Synergistic with smoking.

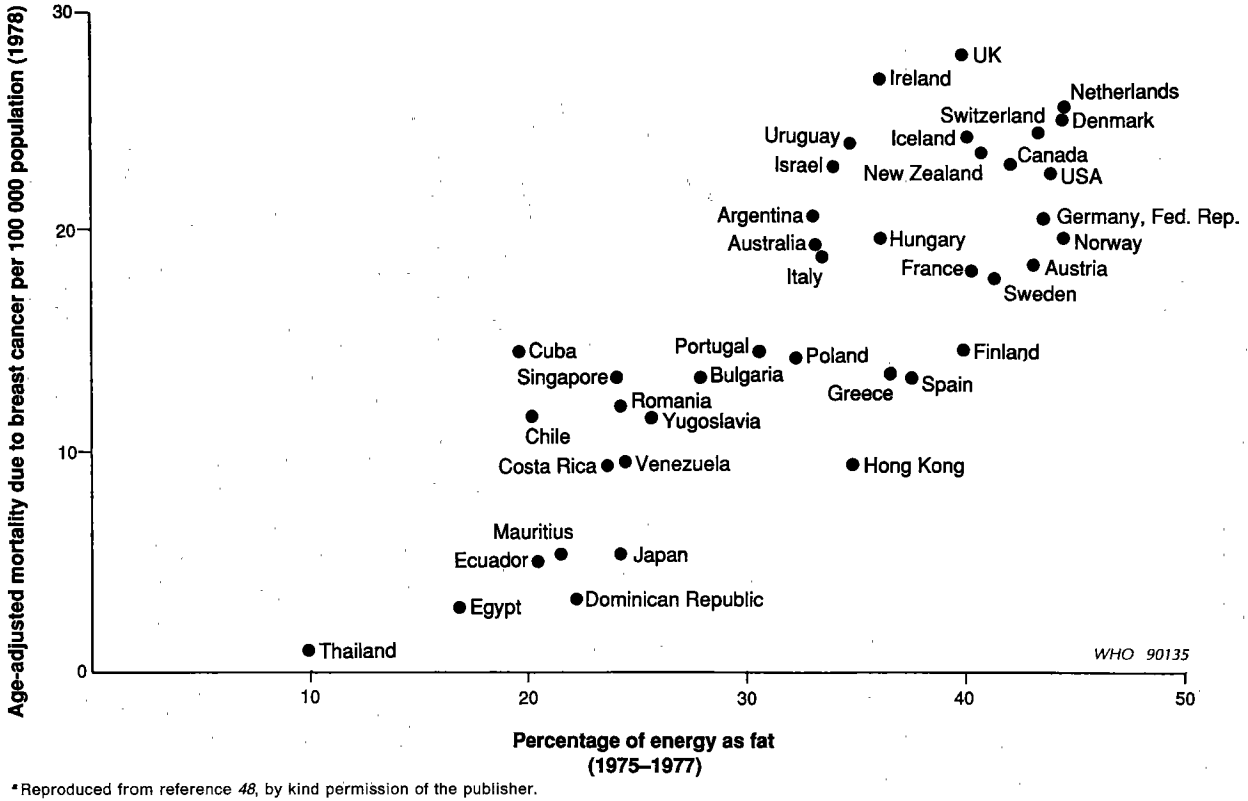
diets are usually low in saturated fat and high in starches and fibre and several vitamins and minerals, including beta-carotene and vitamin A. There is no conclusive evidence that these beneficial effects are due to the high fibre content of such foods.

Sustained heavy alcohol consumption appears to be causally linked to cancer of the upper alimentary tract and liver. Excessive body weight is clearly a risk factor for endometrial and postmenopausal breast cancers, but the association of these cancers with excessive energy intake *per se* is less well established.

High fat intake is associated with cancer at several sites. Certainty about the optimum intake of fat in relation to cancer must await future research, such as controlled trials. In the meantime, international correlation analysis (Fig. 9) and other epidemiological data indicate that fat intakes of less than 30% of total energy will be needed to attain a low risk of fat-related cancers. A reduction in risk is also likely when fat intake is reduced towards 30%, especially if this dietary change is combined with a change in other dietary components (Table 11).

In conclusion, although several lines of evidence indicate that dietary factors are important in the causation of cancer at many sites and that dietary modifications may reduce cancer risk, the contribution of diet to total cancer incidence and mortality cannot be quantified on the basis of present knowledge. Nevertheless, evidence indicates that a diet that is low in total and saturated fat, high in plant foods, especially green and yellow vegetables and citrus fruits, and low in alcohol, salt-pickled, smoked, and salt-preserved

Fig. 9. Dietary fat intake in relation to breast cancer-related death rate[a]



[a] Reproduced from reference *48*, by kind permission of the publisher.

foods is consistent with a low risk of many of the current, major cancers, including cancer of the colon, prostate, breast, stomach, lung, and oesophagus.

3.4 Obesity

The occurrence of obesity in individuals reflects the interaction of dietary and other environmental factors with inherited predisposition. However, since there is little evidence that some populations are more susceptible to obesity for genetic reasons, the differences in prevalence of obesity in different populations are largely attributable to "environmental" factors (especially diet and physical activity). Within a single population, those who become obese usually come from overweight families and there is evidence of heritability for obesity. Thus, from a public health point of view, the challenge is to modify the population's environmental circumstances so that the susceptible individual members of the population are less liable to become obese.

3.4.1 *Obesity in adults*

The state of obesity is normally taken to indicate an excess of body fat, but most analyses of the relationship between body fat and disease have depended on measuring body weight as an index of body fatness. Body weight as a function of height is normally expressed as the body-mass index (BMI):

$$\text{BMI} = \text{body mass in kg/(height in metres)}^2.$$

This expression is useful in adults since it takes account of the increase in weight with increasing height. It is assumed that the same proportions of lean and fat issue are found in people of different height, so that the definition of obesity usually depends on specifying the degree of "excess" weight-for-height. This presupposes an understanding of what constitutes a normal body weight. The definitions are currently based on life insurance statistics, or on long-term epidemiological studies in North America and Europe. There have as yet been no long-term studies to see whether similar grades of excess weight are accompanied by the same risks for those living in developing countries.

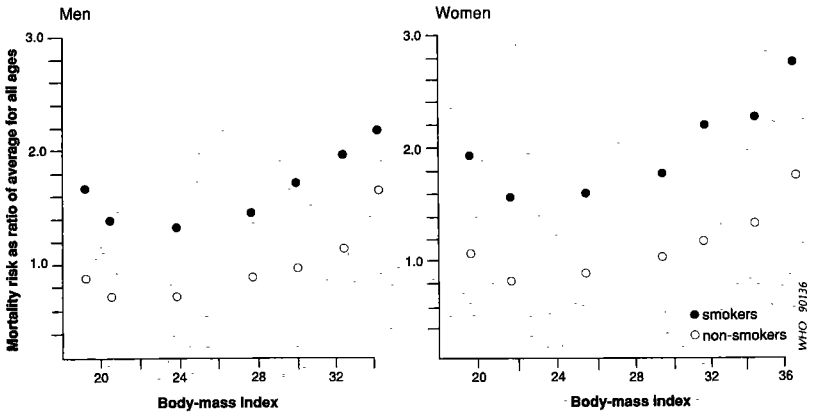
There is, however, substantial evidence that in many cultures obese adults develop the same complications, and so the definitions

derived from affluent communities should be used universally for the present. A BMI of 20–25 is taken as normal for adults in developed countries (*49, 50*). If differences in smoking habits are not taken into consideration, then it can appear that moderate overweight is beneficial. Fig. 10 shows, however, that a BMI of 20–25 is appropriate for both smokers and non-smokers. Moderately overweight adults are often non-smokers, whereas among thin adults there is a higher proportion of smokers, who are at a much greater health risk; this distribution produces a U- or J-shaped curve of mortality against weight in the population as a whole. A small increase in risk is also seen below a BMI of 20 in non-smokers, but an appreciable part of this reflects the lower weight of individuals who are already sick.

It should be noted that these BMI values apply to individuals. A population has to have a average value of about 22 to allow almost all the individuals to fall within the 20–25 BMI range. This implies that a substantial proportion of the adult population in developed countries will be classified as overweight since the population average BMIs are often in the range of 24–26.

When dealing with developing countries, it is suggested that the lower limit of "normality" for individuals of 20 is too high and a limit of 18.5 has therefore been proposed on the basis of the usual

Fig. 10. Body weight, smoking, and death rates for men and women[a]



[a] Reproduced from reference *49*, by kind permission of the publisher. Recalculated from data in reference *51*, with unpublished data from the American Cancer Society.

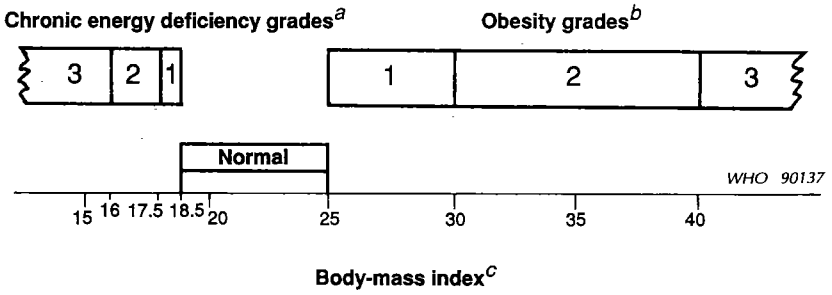
distribution of adult weights. Although evidence is lacking on the health risks associated with a BMI of 18.5 in developing countries, an average BMI of 20 may be considered appropriate for these countries. Thus, for all countries, a range of average BMIs of 20–22 for the adult population is suggested as acceptable.

Three grades of obesity are also identified (Fig. 11), Grade 1 carrying only moderate health risks but Grade 3 being very severe and carrying high risks of hypertension, coronary heart disease, diabetes mellitus, and gastrointestinal disorders, e.g., gallstones. The risks of cancers of the gallbladder, breast (in postmenopausal women), and uterus are increased in obese females, as are perhaps the risks of prostate and kidney cancer in obese males. Weight is a crude measure of adiposity, but only a few small studies have used more specific measures of body fat. There is increasing evidence, however, that fat deposited abdominally presents a greater hazard, so that a waist-to-hip circumference ratio of more than 0.85 is a particular risk.

4.4.2 *Obesity in children*

The BMI has not yet been established as a method of assessing obesity in children and adolescents. The present methods for indicating obesity are largely based on defining a weight-for-height in excess of a reference value. Similarly, a weight below a reference

Fig. 11. Degrees of chronic energy deficiency and obesity in relation to body-mass index



[a] Chronic energy deficiency grades from reference *53*. Grades 1 and 2 require that energy expenditure is also below 1.4 times the estimated basal metabolic rate, based on the weight of the individuals.
[b] Obesity grades from reference *52*.
[c] Body-mass index = mass in kg/(height in metres)^2.

weight-for-height value is taken as indicative of "wasting". The reference values may be taken as 2 standard deviations above and below the National Center for Health Statistics (USA) standard weight-for-height of children below the age of 11 years (*54*). For adolescents, the problem is more difficult because children enter their pubertal spurt in growth and rapidly change their body composition and weight during this growth phase. An FAO/WHO/UNU report on energy and protein requirements gives reference standards for adolescents based on data published by Baldwin in 1925 on weight-for-height, in the absence of modern analyses of adolescent weights and body composition in relation to health (*55*). Further research is needed in this field before definitive reference standards can be set.

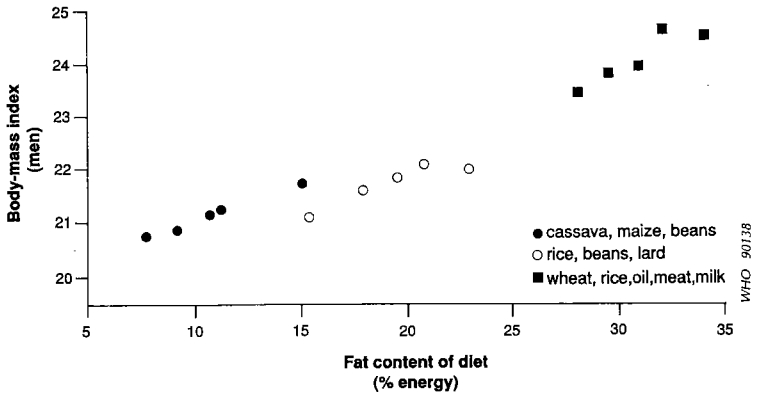
3.4.3 *Factors influencing body weight*

Changes in body fat depend on an imbalance between energy intake and energy expenditure. Thus, obesity develops when energy intake is in excess of expenditure for a sustained period of time.

The causes of obesity can be many, but social and environmental factors that either increase energy intake or reduce physical activity place a greater demand on the normal mechanisms of appetite control and metabolic regulation. As societies become more affluent and mechanized, the demand for physical activity declines. This is apparent in many societies and affects both young and old. The fall in physical activity demands that energy intakes should also be reduced if excess energy is not to be stored as excess fat. Therefore, changes in the environment that affect the level of energy expenditure of children and adults may influence the development of obesity.

There is increasing evidence from experimental animal studies, human physiological measures of energy metabolism, and bioenergetic considerations, that dietary fat is particularly conducive to weight gain. Excess dietary fat is more readily stored than dietary carbohydrate, but fibre-rich complex carbohydrates are also much bulkier and tend to limit energy intake. National and international analyses are in keeping with the concept that, as the proportion of energy derived from fat increases. so does the problem of obesity, particularly in susceptible individuals. Thus, in a national household survey in Brazil (see Fig. 12), statistical analyses that took account of a range of factors, including income and the dietary source of typical nutrients, found that the single most important factor

Fig. 12. Household diet and adiposity in Brazil, according to dietary staples[a]



[a] Adapted from reference *56*. For each dietary pattern, the households studied were split into five groups according to average annual income, with ranges as follows: ●, US$ 99–418; ○, US$ 220–990; ■, US$ 1700–8500.

associated with different degrees of adiposity in households was the fat content of the diet (*56*).

The bulkiness of diets low in fat and high in complex carbohydrates is so great that on some African diets children are unable to derive enough dietary energy for their needs, especially when they are unwell with recurrent infections. This has led to the promotion of fat supplementation of infants' and children's diets to ensure adequate energy intakes. A diet with modest amounts of fat, e.g., 15–20% of energy, may avoid problems of energy deficiency without unduly enhancing the hazards of obesity and other chronic diseases that tend to occur in societies with an average dietary fat content above 30% of energy.

Complex metabolic changes occur in individuals who become obese. The treatment of obesity is notoriously difficult because of the prolonged nature of the treatment, the need to readjust dietary energy intakes and/or physical activity permanently to maintain a reduced weight, and the changes in metabolism and in appetite that tend to minimize weight loss. Thus, a preventive policy seems the only long-term solution to the problem of obesity, with a high-risk group within a society being identified as those with a family history

of obesity, diabetes, hypertension, or hyperlipidaemia. These individuals have a far greater risk of putting on weight or of developing complications with only modest gains in weight.

3.5 Non-insulin-dependent diabetes mellitus

Non-insulin-dependent diabetes mellitus is a chronic metabolic disorder in which there is impairment of the body's capacity to utilize glucose derived from carbohydrate foods, from body stores of glycogen, or from body and dietary protein. This disease, whose onset usually occurs in middle adulthood, is strongly associated with an increased risk of coronary heart disease (*31*), with a range of renal, neurological, and ocular disorders, and, during pregnancy, with adverse effects on the fetus.

This type of diabetes is to be distinguished from insulin-dependent diabetes, and from the gestational diabetes of pregnancy. Diabetes may also be associated with malnutrition; fibrocalculous pancreatic diabetes, for example, is found in Latin America, Africa, and Asia.

Obesity is a major risk factor for the occurrence of non-insulin-dependent diabetes, the risk being related to both the duration and the degree of obesity. Approximately 80% of patients with this form of diabetes are obese. The incidence rate of diabetes is almost doubled when moderate overweight is present and can be more than three times as high as normal in the presence of frank obesity.

The occurrence of diabetes within a community appears to be triggered by a number of environmental factors such as sedentary life-style, dietary factors, stress, urbanization, and socioeconomic factors. The prevalence of non-insulin-dependent diabetes mellitus varies from zero in the highland population of Papua New Guinea, which has retained its traditional life-style, to 50% or more in the Pima Indian and Nauruan populations (*57*).

The most rational and promising approach to preventing non-insulin-dependent diabetes is to prevent obesity. Weight control is of fundamental importance in both the population strategy for the primary prevention of this disorder and the strategy for prevention in high-risk individuals (i.e., persons with impaired glucose tolerance or with a genetic predisposition to diabetes). Physical activity not only improves glucose tolerance by reducing overweight, but also acts independently, by having a beneficial effect on insulin metabolism.

Diets high in plant foods are associated with a lower incidence of diabetes mellitus. In a large follow-up study of Californian Seventh-Day Adventists, the death rate from diabetes mellitus was approximately half that for all whites in the USA (*58*). Moreover, within that same group, vegetarians had a substantially lower risk than non-vegetarians of having diabetes as an underlying or contributing cause of death. Intervention studies in urbanized Australian Aborigines with impaired glucose tolerance have demonstrated beneficial effects of reversion to a traditional diet.

These observations, and other studies, raise the possibility of the primary prevention of diabetes by dietary means. However, there is as yet insufficient evidence to allow specific dietary goals to be given, other than those for the prevention of obesity.

There is a much clearer scientific basis for the prevention of cardiovascular and other complications in diabetic individuals. Annex 2 summarizes recent recommendations offered by expert groups elsewhere.

3.6 Non-cancer conditions of the large bowel

Certain chronic disorders of the large bowel are thought to occur more frequently in association with the typical "affluent" diet. These include diverticular disease of the colon, haemorrhoids ("piles"), and constipation. Low intake of dietary fibre is considered to be a major cause of these disorders.

3.6.1 *Diverticular disease*

The relatively hard, concentrated, slow-moving faeces that result from an inadequate intake of dietary fibre are believed to disrupt bowel motility and increase the internal pressure, causing diverticular pouches that can become chronically inflamed, leading to the condition of diverticulitis. In developed countries, this condition is common after the age of 40 years, when it affects an estimated 20% of the population.

3.6.2 *Haemorrhoids*

When intake of dietary fibre is low, the increased physical effort necessary for defecation may raise the intra-abdominal pressure, thereby increasing pressure in the veins. The surface veins in the

lower rectum are considered to be particularly vulnerable to being stretched and weakened by these pressure changes; eventually these veins form dilated haemorrhoids which can become inflamed, or locally thrombose.

3.6.3 *Constipation*

Chronic constipation occurs in about 10% of adults and 20% of the elderly living in societies with low intake of dietary fibre, e.g., a daily intake of about 20 g of fibre, equivalent to about 12 g of non-starch polysaccharides (NSP).[1]

Constipation occurs under controlled feeding conditions when the daily faecal weight falls below about 100 g; in epidemiological studies, faecal weights below 150 g/day are associated with slower transit times of food through the intestine. Above 150 g/day faecal weight, transit times of food through the bowel are little changed.

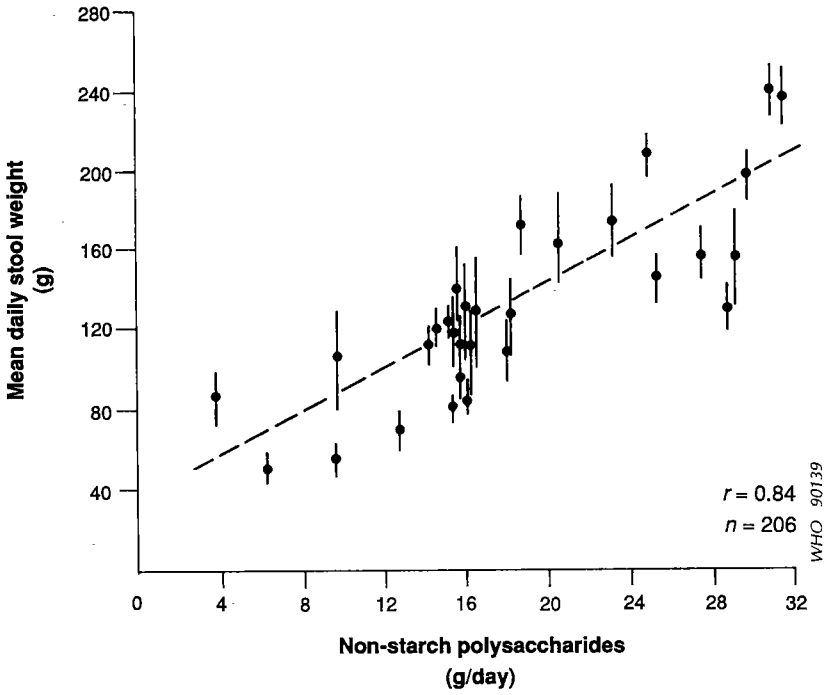
Fig. 13 shows a well defined linear relationship between NSP intake and mean daily stool weights. From studies conducted on mixed British diets to which cereal fibre was added, an intake of NSP of about 22 g is needed to achieve an average faecal output of 150 g, and to minimize the number of individuals with faecal outputs below 100 g. An intake of 22 g of NSP is higher than the typical intake in European and North American countries. In eastern Finland, however, intakes of 18 g of NSP are observed in populations with no problems of constipation or diverticular disease. This practical figure or intermediate target of 18 g of NSP (or the corresponding figure of 30 g of dietary fibre) has therefore been chosen by European and North American committees when specifying dietary fibre goals.

In rural Africa, daily stool weights are much higher than in developed countries, e.g., 450–550 g/day, and similar values have been observed in rural Malaysia. In Indians on an urbanized diet, and South Americans, faecal weights are also high, e.g., 300–375 g in different age groups. As soon as the diet begins to change towards the European pattern, however, faecal weights fall to 170–300 g/day on average.

Although there is a clear association between NSP intake, stool weight, and constipation, further information is still needed on the

[1] These polysaccharides, which contribute to total dietary fibre, are the complex carbohydrate components of the diet other than starches. Since the definition and measurement of dietary fibre *per se* remain uncertain, NSP can be useful as a measurable indicator of fibre intake.

Fig. 13. Mean daily stool output (g) and dietary intake of non-starch polysaccharides in groups of healthy subjects on controlled diets[a]



[a]Redrawn from an unpublished paper prepared by J. Cummings for the Department of Health Committee on Medical Aspects of Food Policy, UK.

amounts of NSP eaten in developing countries, and also on the colonic effects of high intakes of starchy foods, some of which (e.g., maize-based porridges and rice) are eaten after cooling. When starches are cooled or refrigerated, a change in their tertiary structure is likely to occur, resulting in an increase in the proportion passing into the colon after ingestion.

3.7 Gallstones

In gallbladder disease, gallstones (predominantly cholesterol gallstones) form within the gallbladder. Gallstones occur much more commonly in developed countries than in developing countries. Within affluent societies, the prevalence is higher in non-vegetarians

than in vegetarians. In women, the prevalence increases steadily from around 5% in young adulthood to around 30% in old age; in men, the prevalence rates at every age are approximately one-half of those in women. In symptomatic cases (i.e., approximately one-quarter of all cases), surgical removal of the gallbladder or physical or chemical dissolution of the gallstones is often required.

The occurrence of cholesterol gallstones is a result of the presence of supersaturated bile (i.e., a raised concentration of cholesterol in the bile); this tends to occur more often in women than in men. The composition of bile is particularly affected by dietary factors, and is affected adversely by excess body weight. Overweight adults excrete an excess of cholesterol with the bile, but fibre intake reduces the saturation of cholesterol in bile by altering the recycling of bile acids from the intestine, and the amounts of bile and metabolites excreted in the faeces. A starchy diet rich in fibre may therefore be protective, particularly if it helps to limit the problem of overweight.

3.8 Dental caries, sugars, and fluoride

Dental caries has been a human health problem since antiquity. Until the Middle Ages the prevalence of caries was low. Today, it is a very common health problem affecting a large proportion of people in developed and rapidly developing countries. It causes considerable suffering and impairs the quality of life. In addition, caries places a heavy financial burden on public health services, and the problem cannot be controlled by treatment alone.

Historical surveys have demonstrated that, with the introduction of sugars and refined flour and the manufacture of confectionery and sweet baked foods, caries prevalence increased dramatically over a relatively short period. The prevalence of caries in many developing countries is currently increasing rapidly in response to dietary changes associated with increasing use of products containing sugar. This trend is now in striking contrast to that in the industrialized nations where dental caries has been decreasing in the past 20 years, in response to various preventive measures.

Diet can affect teeth in two ways: first, while the tooth is forming before eruption and, secondly, through a local effect after the tooth has erupted. The post-eruption local effect is much more important, and sugars, in particular sucrose, are the most important dietary factor. Sucrose has greater cariogenic potential than starch; biochemical, microbiological, animal and human clinical, and

epidemiological evidence supports a causal relationship between frequent sucrose intake and caries, but many other factors, including individual susceptibility, modify the dental response to sucrose. Glucose alone, or mixed with sucrose and fructose, may also cause caries, so increased emphasis is now being given to the consumption of all free sugars, rather than just sucrose alone, in the development of caries.

Different types of food may increase or decrease caries rates depending on their properties, e.g., stickiness, buffering capacity, or nutrient content. These properties have been intensively investigated by firms that manufacture or sell sugar-containing products in developed countries. Despite suggestions that starch is cariogenic, an extensive review of the evidence (*59*) showed that cooked staple starch foods such as rice, potatoes, and bread appear to be of low cariogenicity. Fresh fruit, despite its intrinsic sugar content, has a lower cariogenic potential, but the addition of sugar to cooked starchy foods increases the development of caries. Less-refined starchy foods may perhaps, by virtue of their fibre content, help protect teeth from dental caries. Children given carbohydrates as wholemeal bread, beans, oats, rice, potatoes, and fruit with some treacle and molasses develop fewer and smaller carious cavities than do children fed a diet containing the level of sucrose and refined flour typical of an affluent society.

Numerous epidemiological studies conducted at the population level suggest that there is a direct relationship between the quantity and frequency of sucrose consumption and the development of caries. The relationship approximates to a sigmoid (S-shaped) curve that rises more steeply as the consumption of sucrose-containing products increases, after which the curve flattens out, i.e., the increase in dental caries is small with further increases in sucrose intake. In general, very little caries occurs in children when the national consumption level of sugar is below 10 kg per caput per annum, i.e., about 30 g/day, but a steep increase may occur from 15 kg upwards. As a result of rising consumption of sugar and other cariogenic substances in developing countries and the absence of adequate fluoride intake, the prevalence of caries is now higher in some developing countries than in many industrialized countries (*7*).

The introduction of new sugar-containing products in developing countries, in particular for use between meals, will lead to increased caries incidence, if not immediately met by effective caries-prevention programmes. There is an obvious dilemma—the

preventive programmes have to be established first, when the disease level may still be low, and the interest for prevention consequently minimal. Nevertheless, if such programmes are not established while the shift in dietary patterns is still taking place, caries will become a major health problem.

Fluoride has toxic effects on teeth and bone when ingested in excess. Dental fluorosis and skeletal fluorosis are well known effects of fluoride excess. The margin of safety between the range for deficiency and toxicity is narrow. A sufficient daily ingestion of fluoride is needed to prevent dental caries, although there is no consensus regarding the exact amount of fluoride needed (figures of 0.7–1.5 mg of fluoride per day from all sources have been discussed in the scientific literature). In most countries, drinking-water supplies about 75% of daily fluoride intake. Many communities, particularly in temperate climates, have water supplies fluoridated to a level of around 1 mg/litre. Keeping in mind the toxic effects of fluoride, and the high daily intake of water in the tropics, there is a need to prescribe both lower and upper limits in terms of total daily intake. A concentration of 0.6 mg/litre in drinking-water has been proposed for tropical countries. The presence of dental fluorosis within a community is an indication that the total intake of fluoride is too high. Countries with a problem of excess environmental fluoride must try to defluoridate their water supplies. Countries with low water fluoride levels may plan strategies to increase the fluoride intake of the population to the appropriate level by adopting known methods of fluoride supplementation.

3.9 Osteoporosis

As the number of elderly in the population increases, problems of old age can be expected to become a greater burden on health services. Already in the developed world many people die following fracture of the femur, which occurs particularly in older women with fragile bones, after a relatively minor fall. By age 90 years, one-third of the women and one-sixth of the men in the USA will have had hip fractures. In 12–20% of cases, the fracture or its complications will be fatal; half of those who survive will need long-term nursing care (*60*). Table 12 shows the incidence of hip fracture in different parts of the world. There is a 20-fold range in rates, even when they are adjusted for age. The higher the incidence, in general, the greater the proportion of women affected. In Yugoslavia, inhabitants of the

Table 12. Incidence rates[a] of hip fracture by region and sex[b]

Country, area or population group	Women	Men	Female/male ratio
United States (Rochester, MN)	101.6	50.5	2.01
New Zealand	96.8	35.2	1.79
Sweden	87.2	38.2	2.75
Jerusalem	69.9	42.8	1.63
United Kingdom	63.1	29.3	2.15
Netherlands	51.1	28.5	1.80
Finland	49.9	27.4	1.78
Yugoslavia[c]	39.2	37.9	1.03
Hong Kong	31.3	27.2	1.15
Yugoslavia[d]	17.3	18.2	0.95
Singapore	15.3	26.5	0.58
South African Bantu	5.3	5.6	0.94

[a] Per 100 000 per year, age-adjusted to USA population 1970.
[b] Based on data originally published in: GALLACHER, J.C. ET AL. *Clinical orthopedics*, **150**:163–171 (1980). Reproduced, by kind permission of the publisher, from CUMMINGS, S.R. ET AL. Epidemiology of osteoporosis and osteoporotic fractures. *Epidemiologic reviews*, **7**:178–208 (1985).
[c] Low-calcium diet.
[d] High-calcium diet.

higher-calcium-intake region have a fracture rate half that of those living on the lower-calcium diet. Nevertheless, low rates were observed in Singapore and among the Bantu, where calcium intakes are lower than in the USA. The age-specific rate of hip fracture appears to be rising rapidly for some poorly defined reason, and is now considered to be reaching epidemic levels in many affluent countries (*61*). Increasing fragility of bone is one major reason for hip fractures, although instability of gait, deteriorating eyesight, and poor neuromuscular reflex coordination also account for the rising incidence of hip fracture with age.

Fragility of bone usually results from osteoporosis in which the amount of bone tissue in a given volume of bone, i.e., the bone density, is reduced. Bone density increases in all parts of the skeleton during childhood and adolescence to reach a peak value at about the age of 20 years and then falls again from the menopause in women and from about age 55 years in men, but at a diminishing rate with advancing age. Women in developed countries lose about 15% of their bone mass in the first 10 years after the menopause, but annual rates of bone loss vary from 0.5% to 2% between individuals. There is a wide range of bone density in healthy young adults, i.e., $\pm 20\%$ of the mean; values below the normal lower limit for the young are defined as osteoporotic. Thus, individuals who reach middle life at the lower end of the normal density range rapidly become osteoporotic with advancing age, whereas those whose mid-life bone density is high may never develop osteoporosis in their natural

lifetime. Factors governing the rise in bone density during growth (e.g., genetic, hormonal, nutritional, and exercise) may therefore prove to be very important in determining whether an individual develops osteoporosis.

Known determinants of bone density have been classified under five headings (*61*): (*a*) lack of estrogen, (*b*) immobility, (*c*) smoking, (*d*) alcohol and drug therapy, and (*e*) calcium intake. Estrogen lack in public health terms relates to the decline in estrogen activity in women after the menopause. Bone density is less in people who drink a large amount of alcohol, and their rate of bone loss is greater for reasons that may relate in part to alcohol-induced alterations in hormone metabolism. The traditional emphasis given to calcium intake reflects the recognition of the importance of calcium in contributing to the density of bone during growth and the value of heavy, initially dense, bones in adult life. Calcium supplements may also be helpful in reducing the rate of bone loss in postmenopausal women, but at levels of intake that are pharmacological rather than nutritionally relevant. It is by no means certain that calcium intake is the key feature determining bone density and bone loss in adult life. High-protein and high-salt diets, for example, are known to increase bone loss.

Fracture risk is a continuous inverse function of bone density; the age-related decline in bone density (together with the increased incidence of falls) produces the age-related rise in fracture incidence that is a feature of all human societies. Women are more prone to these fractures than men because their peak bone density is lower, they suffer accelerated bone loss after the menopause, and they live longer than men. Populations in developing countries appear to be less at risk from fracture than those in developed countries, despite their lower body weights and calcium intakes, possibly because they smoke less, drink less alcohol, do more physical work (which promotes bone formation), and consume less protein and salt (both of which increase obligatory calcium loss from the body).

Little is known of the factors underlying the variation in osteoporosis around the world. Studies in developing countries are few but dietary trends that diminish calcium intakes or increase protein and alcohol intakes may have adverse effects on bone density. A decline in physical activity and an increase in smoking rates are also likely to increase the risk of osteoporosis, and these two factors may explain the currently increasing problem of hip fractures in the developed world, where widespread smoking has

occurred for about 50 years, i.e., during the adulthood of many women and men who are now falling victim to hip fractures.

Recent studies from India clearly show that osteoporosis occurs in population groups subsisting on low-calcium traditional vegetarian diets and living in areas where the drinking-water contains high concentrations of natural fluorides. Similar observations have been made in China and the United Republic of Tanzania. Unlike the osteoporosis of the geriatric population in affluent societies, this type of osteoporosis in the developing countries affects cortical bones throughout the body, and is found in a younger age group. The significant feature, however, is that the combination of a diet low in calcium and a high fluoride intake causes metabolic bone disease characterized by osteoporosis; where dietary levels of calcium are high, no osteoporosis is found despite a high intake of fluoride.

3.10 Chronic liver and brain diseases, and other effects of alcohol

Alcohol consumption has many adverse health effects, many of which are strongly associated with the age of exposure and with the amount consumed. In middle and older age, alcohol consumption influences the risks of a range of chronic disease processes, particularly of the liver and brain.

Liver cirrhosis is the major chronic disease caused by alcohol consumption (*62*). The liver's capacity to metabolize alcohol is surpassed when consumption is excessive; toxicity results and liver cells are destroyed, to be replaced by scar tissue. In developed countries, at least 40% of fatal liver damage is due to alcohol. There is evidence that women are more susceptible to this cirrhogenic effect of alcohol than are men. Long-term excessive consumption of alcohol has a variety of other adverse effects on the gastrointestinal tract and pancreas (*47*).

Another important chronic effect of alcohol consumption is brain damage, entailing mood disorder with confabulation (Korsakoff's syndrome) or a state of delirium and cranial nerve palsies (Wernicke's encephalopathy). It takes about 10 years of heavy drinking to produce these brain damage syndromes; alcohol appears to accelerate aging processes that interfere with the capacity to reason and solve the problems of everyday living.

Alcohol consumption influences the occurrence of coronary heart disease and hypertension (see also section 3.2). While people who

consume low-to-moderate amounts of alcohol are at a slightly lower risk of coronary heart disease than are abstainers, many epidemiological studies have shown that moderate or heavy consumption of alcohol is associated with increased blood pressure, and abstinence from alcohol is followed by a fall in blood pressure. Hypertension contributes to an increased risk of coronary heart disease and stroke.

As discussed in section 3.3, alcohol is a causal factor in various cancers, including cancers of the liver, larynx, mouth, throat, and oesophagus, and, perhaps, cancer of the rectum and, in women, cancer of the breast (*47*).

Alcohol also causes serious health problems at younger ages. There is a characteristic pattern of abnormalities, recognized over the past two decades, in newborn babies of mothers who drink alcohol heavily during pregnancy (*63*). This "fetal alcohol syndrome" involves general retardation of growth, including mental retardation, a characteristic "flat" face with small eyes, lowered bridge of the nose and lack of normal folds, and other anomalies such as congenital heart disease. The fully developed form of the syndrome occurs predominantly in the children of women consuming more than eight alcoholic drinks per day. However, other effects on the fetus, such as low birth weight and an increased risk of stillbirth, occur at levels of intake greater than two drinks (or 20 g of alcohol) per day. Estimates from North America and Europe indicate an incidence of fetal alcohol syndrome of 1–3 per 1000 live births and of some adverse effects in a further 3–5 per 1000 live births. Alcohol is therefore one of the most common causes of birth abnormalities in developed countries.

In adults, particularly young adults, the importance of alcohol in motoring accidents is well established. In developed countries, between one-third and one-half of deaths on the road have alcohol as a significant causal factor. Alcohol is also a major factor in other accidents such as drownings and boating accidents, and in industrial accidents and absenteeism.

3.11 Food contaminants, food additives, plant toxicants, marine biotoxins, and mycotoxins in relation to chronic diseases

Various non-bacterial contaminants of foods cause "acute" diseases, often in epidemic form but sometimes in sporadic form.

These noncommunicable diseases can affect the liver and nervous and skeletal systems and are associated with a high case-fatality rate.

3.11.1 *Food contaminants*

Residues of pesticides and veterinary drugs

Since 1963, FAO/WHO joint meetings have been held regularly to consider pesticide residues in food. Limits have been recommended by the Codex Alimentarius Commission for residues of pesticides and herbicides permitted in agricultural produce, and practical limits for the levels of these residues in the environment have been established for approximately 120 compounds. The number of Codex limits for specified foods now exceeds 3000. In establishing the limits, careful attention is given to good agricultural practice, and the pesticides are evaluated toxicologically for their safety in food. These toxicological analyses include animal testing and studies of the metabolism of the chemicals in humans; groups of workers exposed to higher amounts of these chemicals are also monitored to ensure that there is no evidence of harm. The Codex limits assume that these chemicals are properly used.

However, if the chemicals are improperly used, without rigorous control and monitoring, serious harm may result. Few data are available on the long-term health effects of the misuse of these chemicals, although animal data suggest the possibility of a profound long-term impact on health.

Residues resulting from the application of drugs in animal husbandry and veterinary medicine have been under review by the Joint FAO/WHO Expert Committee on Food Additives for several years. Codex-recommended limits have been established, giving careful attention to good husbandry practice. No evidence of harm to humans has been found when approved drugs are used and Codex-established limits are not exceeded.

Heavy metals

Serious chronic diseases have been reported when foods containing large quantities of cadmium, lead, or mercury have been ingested over extended periods of time. Continuous surveillance is needed to ensure the safety of the food supply.

Other environmental contaminants

Evidence of disease caused by other environmental chemicals such as polychlorinated biphenyls and dioxins is rare. This may be due to large-scale underreporting, to the great difficulty in correlating exposure with the possibly latent effects, or to the fact that these chemicals occur generally only in minute amounts in food.

3.11.2 *Plant toxicants*

Toxicants in edible plants and poisonous plants resembling them (mushrooms, certain wild green plants) are important causes of ill-health in many areas of the world. In some places, the poorer sections of the population eat plants known to be potentially toxic (e.g., *Lathyrus sativus*) in order to combat hunger. Pyrrolidizine alkaloids are frequent contaminants of edible millet, and cause liver diseases. Contamination of edible oil can cause epidemic dropsy and has been linked to other epidemics.

3.11.3 *Marine biotoxins*

A WHO Expert Committee convened in cooperation with FAO in 1973 considered fish and shellfish hygiene (*64*), including the principal diseases resulting from the ingestion of, or contact with, fish and shellfish, the principal diseases of these animals, the biotoxins of marine fish and shellfish, the surveillance and epidemiological investigation of fish- and shellfish-borne diseases, and the safe handling of fish and shellfish and their products; in addition to the Committee's report (*64*), two books on these subjects have been published by WHO (*65, 66*).

Surveillance of foodborne disease due to fish and marine biotoxins is grossly inadequate in many regions of the world, especially in developing countries, in which the number of such outbreaks is not known with any accuracy.

3.11.4 *Mycotoxins*

At least 150 different types of mould, when growing on certain foods under suitable conditions, produce substances (mycotoxins) that are toxic to humans or animals (*67*). Because of the formation of mycotoxins, the general problem of mould growth on foods has extensive agricultural and economic implications beyond obvious

food spoilage. This has been of particular importance when developing programmes for growing protein-rich foods based in part on peanuts, cottonseed, soya, and other plant sources, for use in the alleviation of malnutrition.

The most extensively studied mycotoxins, e.g., aflatoxins, are generally resistant to normal food-processing techniques. Some mycotoxins are powerful carcinogenic agents in animals and probably also in humans; others cause ergotism, alimentary toxic aleukia, and other diseases.

The control of mycotoxicoses requires that mould contamination in food and animal feed should be prevented or reduced to harmless levels. This demands good agricultural practice in harvesting, drying, handling, storage, transportation, and distribution procedures (*68*).

3.11.5 *Food additives*

Food additives are used for four main purposes:

—to preserve the nutritional quality of foods;
—to maintain the safety of food by inhibiting the growth of bacteria or other organisms that might cause serious illness;
—to improve the consistency of foods, for example to make them thicker or easier to spread;
—to make food look more attractive in colour and to improve the taste.

Since 1956, food additives have been under continuous toxicological evaluation by the Joint FAO/WHO Expert Committee on Food Additives. The Codex Alimentarius Commission has established maximum permitted limits for the safe use in foods of evaluated additives. Specifications for the identify and purity of food additives have also been published by FAO and WHO to ensure that only those of food-grade quality are used. The effects of additives on health are under continuous review to ensure that they do not lead to ill-health in the amounts recommended by the Codex Alimentarius Commission. There is, however, the risk that the illegal use of chemicals in food can mask poor quality, disguise food deterioration, or constitute a deliberate adulteration of the product. The adulteration of food can, in certain circumstances, be very harmful to health besides damaging the consumer's perception of the identity and value of food.

Some traditional food additives (e.g., curing salts, smoke) are considered to be risk factors for certain diseases, for example for hypertension and some cancers. Their use should be carefully monitored or, where possible, they should be replaced by other preservation methods proved to be safe. Rules for the safe preparation of food for immediate consumption have been published by WHO (see Annex 3).

4. INTEGRATING INFORMATION ON NUTRITIONAL AND DIETARY RELATIONSHIPS TO DISEASE

4.1 Nutrients

Section 3 summarized the relationship of some aspects of the diet to the development of specific chronic diseases. Many national and international committees have considered in detail the causes of cardiovascular diseases, cancers, and other conditions of public health importance. However, it is essential to integrate the conclusions if a coherent public health policy is to be developed.

In theory, it is possible for a specified intake of a nutrient to increase the risk of one disease while decreasing the risk of some other disease; further, this relationship could itself vary for different segments of the population. The policies for preventing those two diseases could therefore be very different, and could lead to a complicated set of policies linked to different subsections of the population. Fortunately, this problem does not seem to arise, since the dietary recommendations for preventing most of the conditions prevalent in developed countries are very similar (see section 3). It is still necessary, however, to consider the optimum intake of specific nutrients needed to prevent each condition, and whether any inconsistencies occur.

It is also important to assess the relationship of particular foods or diets, rather than nutrients, to certain diseases since there may be insufficient evidence to identify the specific nutrients responsible for the effects of particular diets. Given the remarkable variety of dietary habits in different countries, it would also be helpful to know which of several different diets are compatible with long-term health. This section therefore attempts to integrate current knowledge about different components of the diet; it also deals in some detail with diets high in plant foods and with alcohol intake.

4.1.1 *Dietary energy*

The energy utilization of an individual is finely controlled by physiological mechanisms, and adjusts to changes in the individual's size and pattern of physical activity. Deliberate decreases in energy intake lead to progressive changes in body weight, to additional small adaptive metabolic changes amounting to about 10% of total energy expenditure, and perhaps to alterations in physical activity. The reproductive performance of women appears to be impaired by insufficient energy intake, and a child's growth will be slowed or stopped and spontaneous physical activity restricted when food intake is inadequate. If food is freely available, then food is consumed in response to the demands of the body; the larger the individual and the more physically active, the greater the energy need. However, the metabolic flexibility of the body is limited, and it is difficult to introduce major changes in energy intake for more than a few days before hunger or satiety signals will tend to limit further weight changes. Changes in the energy density of foods, such as brought about by introducing sucrose- and/or fat-rich foods low in complex carbohydrates and fibre, will produce effects that will become apparent over a period of weeks or months. The cumulative effect of a sustained 2% discrepancy between energy intake and energy expenditure can lead in an adult to a 5 kg weight change over a period of one year. Thus, consideration of the selective effects of different sources of energy in promoting overweight and obesity is important in public health terms.

The energy intake of populations varies substantially, but this does not necessarily reflect differences in energy requirements. A recent analysis of per caput energy requirements of different populations conducted for FAO has assessed the importance of a variety of factors in determining the energy needs of different populations (*69*). In developing countries, the population is predominantly young with therefore a lower average energy requirement and the adults are also usually shorter with a lower body weight. Although physically more active, particularly in rural areas, men and women in developing countries usually have a lower energy requirement than North Americans simply because their body weight is lower.

The smaller body size reflects an earlier constraint on physical growth and development. In addition, physical activity itself, although at a relatively high level, may be restricted as an adaptation

to insufficient energy intakes (*55*). Thus, as populations of developing countries gain access to unlimited food and benefit from improved conditions of water and food hygiene, and as the prevalence of infectious diseases declines, they may be expected to grow taller and possibly to become more active. The future food needs of such countries will therefore increase even if the population does not increase. Population growth remains, however, the dominant factor determining projected food needs.

Once the overriding need for food energy to meet the requirements for children's growth and adults' economic and social activities has been met, then the effects of different sources of energy can be considered. Protein requirements are readily met in children and adults eating a varied diet based predominantly on cereals and pulses, and these diets, which are consumed by the majority of the world's population, provide on average about 10–15% of the total energy from protein. There are no known advantages from increasing the proportion of energy derived from protein, and high intakes may have harmful effects in promoting excessive losses of body calcium and perhaps in accelerating an age-related decline in renal function.

On average, 85–90% of dietary energy will be derived from non-protein sources, i.e. from carbohydrate, fat, and alcohol. The arguments presented in this report discourage the use of alcohol as an energy source and encourage a limitation on fat intake. The lower limit on fat intake is based upon consideration of both essential fatty acid requirements and of energy density. In practice, diets low in total fat are seen most frequently in developing countries. In that setting, the diets tend to be high in "bulky" foods and concern exists that the total volume of food may restrict energy intake in young children and the elderly. The Study Group concurs with an earlier assessment of this situation (*70*) and proposes that the lower limit for the average fat intake by a population group be set at 15% of dietary energy. At this level of intake, needs for essential fatty acids can readily be met and the problems associated with the bulk of food can be handled. Appreciably higher fat intakes may nevertheless be needed by infants and very young children, and particularly in countries where food practices must allow catch-up growth of children with various degrees of malnutrition.

4.1.2 *Fat consumption*

As the total fat content of the diet increases, an increasing proportion of persons within the population—including, particularly, the most susceptible individuals within that population—develop obesity with all its complications, e.g., diabetes and hypertension. Studies on the control of energy balance in humans have not yet shown differences between saturated and unsaturated fatty acids, so the total amount of fat seems to be the important consideration in the prevention of obesity. There are no good systematic studies on the prevalence of obesity in relation to the proportion of fat in a nation's diet, but crude analyses of the national food supply (from FAO figures) in relation to the average body-mass index, measured as part of the recent major Intersalt study on adults, suggest that a mean body-mass index of 22–23 is associated with a dietary fat content that provides 15–20% of energy (*11*). In Brazil, the mean BMI is about 22 and the fat content of the diet amounts to 18% of energy intake, on average. Fig. 3 (page 30) shows that in Brazil the prevalence rate of obesity is low in children. European figures suggest that, for adults, a mean BMI of 25–26 is associated with a dietary fat content that provides 35–40% of energy. There is then a prevalence of Grade 1 obesity of about 40% in middle-aged men and women. On the grounds of obesity alone, therefore, any increase in fat intake beyond perhaps 20% of energy should be avoided.

Table 11 (page 67), which summarizes the links between diet and cancer, suggests that a high intake of total fat may also promote the development of a number of cancers. The evidence cannot be considered sufficiently strong to be termed causal, but most expert groups now consider it prudent to reduce fat intakes in Western societies from the prevailing figure of about 40% of energy towards the 20–30% figure (see Annex 4).

Total fat intake has also to be considered in relation to cardiovascular disease. The level of total fat intake does not affect blood cholesterol concentration unless appreciable amounts of saturated fat are consumed. Fat intake as such may, however, promote the development of hypertension. Total fat intake, therefore, needs to be restricted on this basis. Again, a figure of 30% of energy or less has been suggested as acceptable and this value is also advocated in the management of diabetes mellitus, where the risk of cardiovascular complications is very high (see Annex 2).

One further reason for specifying a population mean intake of total fat within the range of 15–30% of energy for the prevention of cardiovascular disease is the need to restrict saturated fatty acid intake. Most diets in developed countries contain an excess of saturated fatty acids, so policies that lead to a fall in total fat intake are also likely to reduce the diet's saturated fat content.

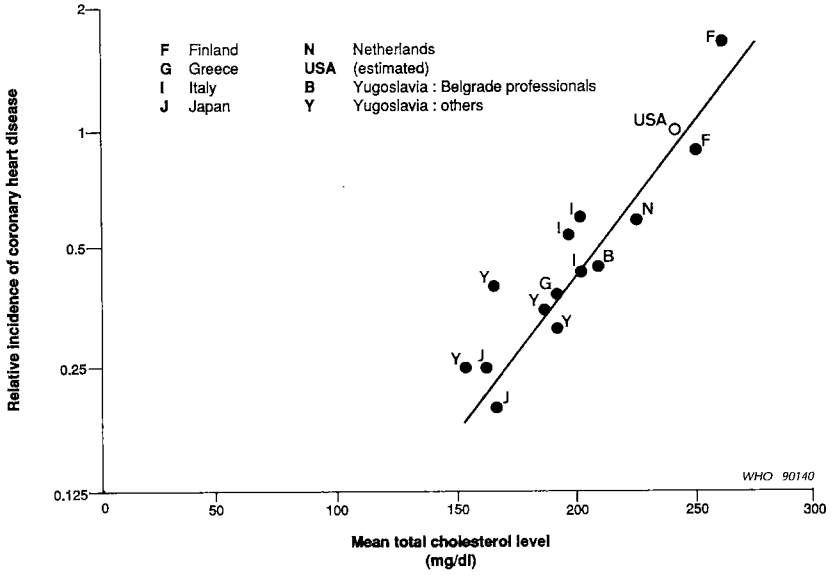
Thus, there is a coherence in the prevention policies dealing with all these conditions. It is therefore possible to identify an upper limit for fat intake of 30% of energy for the population average. However practical considerations in some developed countries suggest that it would be sensible to have an intermediate shorter-term target of 35% as the upper limit, to allow the changes in the food and agriculture industries to occur progressively without any major disruption caused by extreme and abrupt changes in policies. These difficulties emphasize, however, the importance that developing countries should attach to arresting uncontrolled increases in the fat content of their diets (see section 6).

4.1.3 *Intakes of saturated fatty acids*

Saturated fatty acids and cholesterol are not essential nutrients and their importance relates directly to their effects in increasing blood cholesterol concentrations and promoting the development of coronary heart disease. As noted previously (section 3), no lower limit to serum cholesterol has been identified below which a beneficial reduction in coronary heart disease cannot be expected (Fig. 14) so national nutrition policies should seek to minimize intake of saturated fatty acids. These fatty acids may also be specifically involved in promoting cancers, particularly of the colon and breast, although the evidence remains inconsistent. The main justification for limiting saturated fatty acid intake should therefore be the prevention of coronary heart disease.

Adults in rural areas of developing countries where they have particularly low blood cholesterol concentrations, of 3.24–3.89 mmol/l (125–150 mg/dl), eat a diet with a saturated fatty acid intake of 3–5% of energy and a total fatty acid intake of 5–10% of energy; these intakes represent the practicable minimum for such regions. The WHO Expert Committee on the Prevention of Coronary Heart Disease (*31*) advocated a limit of 10% of energy to be derived from saturated fatty acids. Recent evidence reinforces the validity of this recommendation, but northern European committees have taken a

Fig. 14. Serum cholesterol level and incidence of new coronary heart disease (any type) in different populations and subgroups[a]



[a]Calculated from reference *30*, adapted by R. Peto, and redrawn with permission.

pragmatic intermediate goal of 15%, while advocating a more rigorous change of diet to bring saturated fatty acid intakes below 10% in individuals at high risk, e.g., those who are overweight, hypertensive, or hyperlipidaemic. Since the increase in mortality (predominantly from coronary heart disease) is progressive throughout the body-weight range (Fig. 15) (*49*), and since the same is true for blood pressure (Fig. 7, page 59) and blood cholesterol concentrations (Fig. 14), the definition of high-risk groups within a population is necessarily somewhat arbitrary and based on the relationship of the group to the average for the population—which may itself be considered at high risk. Thus the choice of intermediate nutrient goals is a policy decision based on issues other than health, e.g., economic or social considerations.

Dietary cholesterol also has a significant impact on blood cholesterol concentrations, but its effect is less than that of changes in intake of saturated fatty acids. A policy of limiting cholesterol

Fig. 15. Mortality in relation to body weight for men aged 15–39 years[a]

[a] Redrawn from reference *49*, by kind permission of the publisher. Data recalculated from the Build Study. Men were followed up for 22 years. Mortality is expressed as a percentage of the average for the entire group.

intake to less than 300 mg/day seems to have almost universal agreement.

4.1.4 *Total carbohydrates*

In all diets, total carbohydrate intake consists mainly of complex carbohydrates, the remainder being made up of free or unrefined sugars.

The basis for specifying a national target for intakes of free sugars of 15–20 kg per person per year, provided that fluoride intake is sufficient, has been set out previously (*74*). This intake amounts to 40–55 g of free sugars daily, which corresponds to about 6–10% of the daily energy intake. Other reasons for limiting intakes of free sugars have been cited, including concerns about the development of obesity and, thereby, diabetes and cardiovascular disease, but there is little evidence that sucrose or other free sugars have specific effects

that would warrant a lower intake than that recommended to minimize the problem of dental caries.

Any greater intake, however, could be disadvantageous in that free sugars in the diet displace other energy sources such as starches which, when obtained from cereals, pulses, and vegetables, are accompanied by a wide variety of micronutrients. It therefore seems appropriate to obtain 50–70% of energy from complex carbohydrates derived from these sources. Given the widespread concern about vitamin and mineral deficiencies over the last 50 years, it would be unwise to prejudice the nutritional gains obtained by improving the nutrients available in the diet by the addition of a nutrient-free source of energy. Similar arguments can apply to the increase in dietary energy from fat which provides only a few nutrients, e.g., fat-soluble vitamins. Alcohol is also an important energy source which is often accompanied by few if any nutrients. Thus, sucrose, fat, and alcohol are all capable of displacing other energy sources of nutritional quality because appetite is primarily geared to the control of energy intake.

As the proportion of the elderly increases in a population, the issue of the nutrient density of the diet will also become more important because energy requirements fall progressively in the elderly, although their needs for protein, calcium, iron, and other nutrients either remain the same or actually increase. Thus, the nutritional quality of the diet needs to change in old age, i.e., at an age when people usually seem to maintain their traditional patterns of eating. A policy of maintaining a high quality diet throughout life therefore seems appropriate; both sucrose and other free sugars and, to a lesser extent, fat should therefore be limited on nutritional quality grounds alone. Given a suggested intake of 50–70% of energy from complex carbohydrates, an upper limit of 10% of energy from free sugars would appear to be the maximum if an appropriate 10–15% of dietary energy is to be derived from protein and 15–30% from fat.

4.1.5 *Complex carbohydrates*

The relationships seem to be consistent between the levels of complex carbohydrate in the diet and the risks of the various diseases reviewed in section 3. The proposals that 50–70% of energy should come from complex carbohydrates are based on a variety of considerations that do not necessarily relate to the nutritional

qualities of these food components as such. They relate mainly to the recognition that diets rich in complex carbohydrates are useful in preventing excessive weight gain, limiting hyperlipidaemia, and managing diabetes, and seem to favour a lower incidence of a variety of cancers.

Nutritional research into the positive benefits of complex carbohydrates as such is limited, but the benefits from the minerals and vitamins associated with them are many. Many of the plant sources of complex carbohydrates provide, for example, the essential fatty acids, rich sources of calcium, zinc, and iron, and a variety of water-soluble vitamins. Complex carbohydrates can affect colonic function as well as the normal absorptive mechanisms in a variety of ways that may contribute, by as-yet-unknown mechanisms, to their many nutritional benefits.

4.1.6 *Cereal intakes*

Cereals provide the principal source of starch in most communities, and the arguments in favour of a substantial cereal intake are widely cited, as noted in section 3. Cereals also provide a rich source of dietary fibre; cereal fibre is particularly resistant to bacterial degradation in the colon and thereby contributes to faecal bulking and the avoidance of constipation. For adults, the suggested minimum average intake of non-starch polysaccharides (NSP) is 22 g/day (see section 3 for background). This proposal is based exclusively on the need to avoid constipation and the associated problems found in affluent societies with low fibre intakes. A high starch intake also contributes to faecal bulking, because resistant starch, as well as normal undigested starch, enters the colon to provide a substrate for colonic metabolism.

As yet, too little is known about the relative advantages of high-starch diets with a moderate rather than a high fibre content, so the suggested NSP target of 22 g/day may change in the light of new research. This figure of 22 g of NSP corresponds to a value of about 37 g of total dietary fibre, measured by the older enzyme methods of the 1970s, which is consistent with the figure suggested for the management of diabetes or of individuals at high risk of coronary heart disease in North America or Europe. Therefore, a figure of 22 g of NSP, or 37 g of total dietary fibre, is suggested as a target for the present, this fibre to be derived predominantly from cereal and vegetable sources. It should be recognized, however, that the second

figure of 37 g depends greatly on the type of diet consumed in a country, because different sources of food give different values for total fibre by the rather unreliable older methods. The analysis of NSP is more consistent, but there is as yet no international agreement on fibre measurement techniques.

For adults, an upper recommended average of 32 g of NSP can be suggested from the progressive increase in faecal output as NSP intake rises (Fig. 13, page 77). Other data suggest that, above an intake of 32 g of NSP, the response in faecal output is less predictable, and that this high intake is more than adequate to ensure that the whole adult population is prevented from having constipation. A daily intake of 32 g of NSP should therefore represent an upper limit. The lower limit is specified as 22 g/day to reduce the likelihood of adults having a faecal output below 100 g/day.

The relationship illustrated in Fig. 13 was derived from studies of European and North American adults. Account of the lower food intakes of children, and of adults of smaller size and stature, must therefore be taken in deriving population averages. Values have been derived by taking the average energy requirements for countries with many children and adults of short stature, to ensure that too high a value is not chosen in absolute terms. This approach leads to lower and upper average limits for the whole population of about 16 g and 24 g of NSP.

To simplify the handling of the fibre data, the information can also be expressed in rounded figures as a proportion of energy. Thus, the average lower and upper limits for NSP are 2.2 g/MJ and 3.2 g/MJ, respectively (9 g/1000 $kcal_{th}$ and 13 g/1000 $kcal_{th}$). In terms of total dietary fibre, the corresponding figures are about 3.7 g/MJ and 5.3 g/MJ (15 g/1000 $kcal_{th}$ and 22 g/1000 $kcal_{th}$). These values allow the more ready application of the recommended limits to distinct population groups of different age structures.

One potential source of concern with fibre-rich diets is whether their phytate or oxalate content will limit the availability of minerals such as calcium, zinc, and iron. Studies from the eastern Mediterranean region suggest that very high intakes of unleavened bread, where the cereal phytate has not been destroyed by the endogenous phytase of the grain, do lead to problems of mineral malabsorption. However, this seems to be a problem of food preparation rather than of the diet as such. In human physiological studies, exchanging full grain cereals for refined starches low in fibre does not lead to calcium, zinc, or iron malabsorption, because the

whole grain provides an additional intake of the minerals that compensates for any reduced mineral availability. Oxalate-rich foods such as spinach do, however, limit mineral absorption. The intake of fibre from a mixed diet providing the maximum proposed adult limit of 32 g of NSP has been shown to allow the maintenance of mineral balance, but this conclusion may not apply to fibre-rich foods made by the addition of bran, which contains extra phytates as well as fibre.

Further research in the field is needed, but for the present the lower and upper population goals of 16 and 24 g of NSP per head per day seem appropriate.

4.1.7 *Intakes of vegetables, fruit, and pulses*

Vegetables and fruits are a rich source of a number of nutrients. They are relatively low in energy but high in fibre, vitamins, and minerals. Thus they form a useful component, contributing to the balance of the diet. In addition, although no precise dose–response relationships between intakes and disease have been reported, there seems to be some consistency in the evidence that vegetables and fruits play some protective role in preventing the development of cancers (see Table 11, page 67). It is not known whether their effects on cancer development are nutritionally based, e.g., attributable to the provision of vitamins E and C and beta-carotene involved in free-radical scavenging, or whether other components of these foods exert powerful effects.

Available information (*1*) indicates that, in 1979–81, vegetables and fruits together, globally, provided about 4.5% of energy supply. This figure is believed to be an underestimate because of the consumption of non-marketed vegetables and fruit in many countries. This amount of energy would correspond to about 200 g of vegetables or fruit per day per person. Pulses, nuts, and seeds were estimated to contribute 2.4% of the energy in developed countries and 5.6% in developing ones.

With a view to providing a balanced and sufficient intake, China has recently adopted a national goal of 400 g per day of vegetables and fruits. On the basis of observed national intakes for regions or countries, e.g., southern Italy and Greece, where high intakes are associated with low rates of coronary heart disease and of some types of cancers, a per caput intake of 400 g/day of vegetables and fruits (potatoes, other tubers, and cassava not included) is

considered desirable, and of this 30 g/day should be pulses, nuts, and seeds. Potatoes, roots, and other tubers are also a rich source of nutrients in many countries where they may substitute for cereals.

4.1.8 *Salt*

On a population level, the habitual level of salt intake is strongly related to normal blood pressure. In populations with a salt intake of less than 3 g/day, no rise in blood pressure with age was observed, in contrast to populations with a salt intake of more than 6 g/day. Salt may also play a role in the causation of stomach cancer. Therefore an average salt intake of less than 6 g/day is recommended.

4.2 Potential health consequences of diets high in plant foods

The nutrient goals recommended in Table 13 (see page 108) translate into a diet that is low in fat (especially in saturated fat) and high in carbohydrate (especially in complex carbohydrate). Such a diet would be characterized by frequent consumption of vegetables, fruits, cereals, and legumes, rather than by substantial intakes of whole-milk dairy foods, fatty meats, and free sugars. A substantial amount of epidemiological and clinical data indicates that a high intake of plant foods and complex carbohydrates is associated with a reduced risk of several chronic diseases, especially coronary heart disease, certain cancers, hypertension, and diabetes (see section 3).

Although some of this evidence is derived from observational studies of religious groups such as Seventh-Day Adventists, who may differ from the general population in more than just their dietary practices, much of the evidence comes from epidemiological studies, or from controlled trials. Overall, the evidence indicates that diets high in plant foods entail lower risks of various chronic diseases than the current diets of affluent communities.

The possibility of adverse consequences from consuming diets high in plant foods must also be considered. For example, at the population level the consumption of starchy foods is correlated with a higher risk of stomach cancer, and a positive association between starchy foods and stomach cancer has been reported in several, but not in all, epidemiological studies. This positive association is probably attributable to the frequent consumption of salted, pickled, and smoked foods, which tends to accompany a high consumption

of starchy foods. Overall, the evidence indicates that diets high in plant foods, and low in salted, smoked, and pickled foods, are associated with a low risk of several cancers, including stomach cancer.

The iron obtained from vegetarian diets may be all in the inorganic form, if no animal foods are consumed; such iron is less well absorbed than iron from non-vegetarian diets, which includes haem iron in meat. However, the absorption of inorganic iron is enhanced by the simultaneous consumption of vitamin C, which is abundant in most plant foods. In North America, iron deficiency anaemia appears to be no more prevalent among vegetarian women than among non-vegetarian women.

The type of diet high in plant food that might be derived on the basis of the proposed nutrient goals—and that may contain foods of animal origin—should be distinguished from the various vegetarian diets prevalent in certain developing and even some developed countries. It is not possible to evaluate the health benefits of diets high in plant foods from studies in developing countries. "Vegetarianism", or a primary reliance on foods of plant origin, is prevalent in many forms in developing countries, especially in India, but the macronutrient composition (or the distribution of food groups) in these vegetarian diets may differ from diets based on the nutrient goals proposed here. For example, diets of low-income Indians are often cereal-based and low in fat and sugar, but they are also often devoid of vegetables and fruit and deficient in various nutrients. Alternatively, the more affluent urban populations in India often consume a fruit- and milk-based vegetarian diet which, while relatively low in saturated fat, is increasingly high in total fat, sugar, and salt. Although the heavily cereal- and fruit-based diet of the urban middle class in India might be expected to entail a low risk of chronic diseases, there are no relevant epidemiological data available.

The risk of deficiencies of protein and of other nutrients may increase as the number of different foods included in individual diets decreases. Diversity in the availability and use of foods must therefore be a key component of any programme aimed at maintaining or improving nutritional health. The role of foods of animal origin is dealt with in section 2.

4.3 Alcohol

Excessive alcohol consumption increases the risk of hypertension (and stroke), liver cirrhosis, alcoholic brain damage, and various cancers. Although there is some evidence that beneficial effects may occur at low levels of alcohol consumption (around 10–20 g of alcohol per day), including some reduction in risks of coronary heart disease and of cholesterol gallstone formation, this remains uncertain.

The higher the average alcohol consumption within a population, the more frequent the associated health problems become. However, because of the very skewed distribution of alcohol consumption, it is not possible to specify an average population level of alcohol consumption that is acceptable from a public health point of view. In many developed countries, alcohol consumption is a long-established and entrenched social behaviour. The public health challenge in these countries is to reduce the average level of consumption among drinkers to a low level (e.g., to around 4% of total energy intake), *and* to eliminate alcohol abuse and high-risk behaviour (especially drinking alcohol in association with driving a motor vehicle). In countries where alcohol consumption is not an established social behaviour or is not acceptable, it is desirable that abstinence be maintained.

4.4 Importance of physical activity

The energy expended in physical activity may be conveniently described in quantitative terms as the proportion of energy expended in excess of the total amount needed to maintain bodily function under basal conditions (basal metabolic rate) and to provide for normal growth, pregnancy, and lactation, and for the energy cost of ingesting and processing food (dietary-induced thermogenesis). The component needed for physical activity often constitutes no more than 20–30% of the total energy expenditure under everyday living conditions. This amount of dietary energy should be enough to maintain physical fitness and to allow for a variety of economically necessary and socially desirable activities.

During the process of development, communities often evolve, from rural societies where physical activity is needed for agricultural production, to more industrialized, urbanized, and affluent societies where the demand for physical labour becomes progressively less. Sedentary activities under these conditions become a more

prominent feature. Given the intrinsic advantages of physical activity (see below), it is unfortunate that the decrease in the demand for physical work during normal occupational activity is not counterbalanced by a substantial increase in leisure-time activity. There is, therefore, a progressive decline in total energy expenditure from physical activity as societies become more affluent and industrialized.

Inactivity and a sedentary life-style have several adverse consequences for health. Research now clearly indicates that several physiological functions associated with health may be compromised by a decline in physical exertion. A summary of the body functions affected by the decline in physical activity is set out in Fig. 16, which also enumerates the multiple benefits of regular exercise.

Special attention should be paid to the maintenance of appropriately high levels of physical activity at earlier ages, as many diet-related disturbances (e.g., obesity) develop during childhood and adolescence. Daily activity patterns at these ages are being increasingly influenced by very sedentary leisure-time activities, such as watching television or the playing of electronic games for several hours per day.

It is not possible to differentiate clearly between the benefits of short periods of intense exercise and the benefits that accrue from prolonged periods of modest activity and which are, on a 24-hour basis, of a similar energetic significance. It appears that the effects of prolonged periods of moderate activity, such as occur among populations in developing countries, are as beneficial as the physiological changes that occur in response to the episodic bouts of vigorous exercise characteristic of sporting, leisure-time activity in affluent societies. On this basis, it seems reasonable to conclude that the maintenance of reasonable levels of physical activity on a daily basis should be the principal concern of societies where mechanization and leisure-time activities are conducive to a sedentary life-style. (In order to maintain cardiovascular "fitness", it has been suggested that aerobic activity sustained for periods of at least 20 minutes, three to five times per week at a level of between 50% and 85% of the maximum oxygen uptake capacity, is appropriate.)

Various clinical trials and epidemiological studies have established the association of regular physical training with improved glucose tolerance and reduced insulin levels. Physical activity also increases the concentration of circulating high-density